A35

The Kent Incorporated Society for Promoting Experiments in Horticulture

ANNUAL REPORT 1951

EAST MALLING RESEARCH STATION

Near MAIDSTONE
KENT

1st October, 1950 to 30th September, 1951

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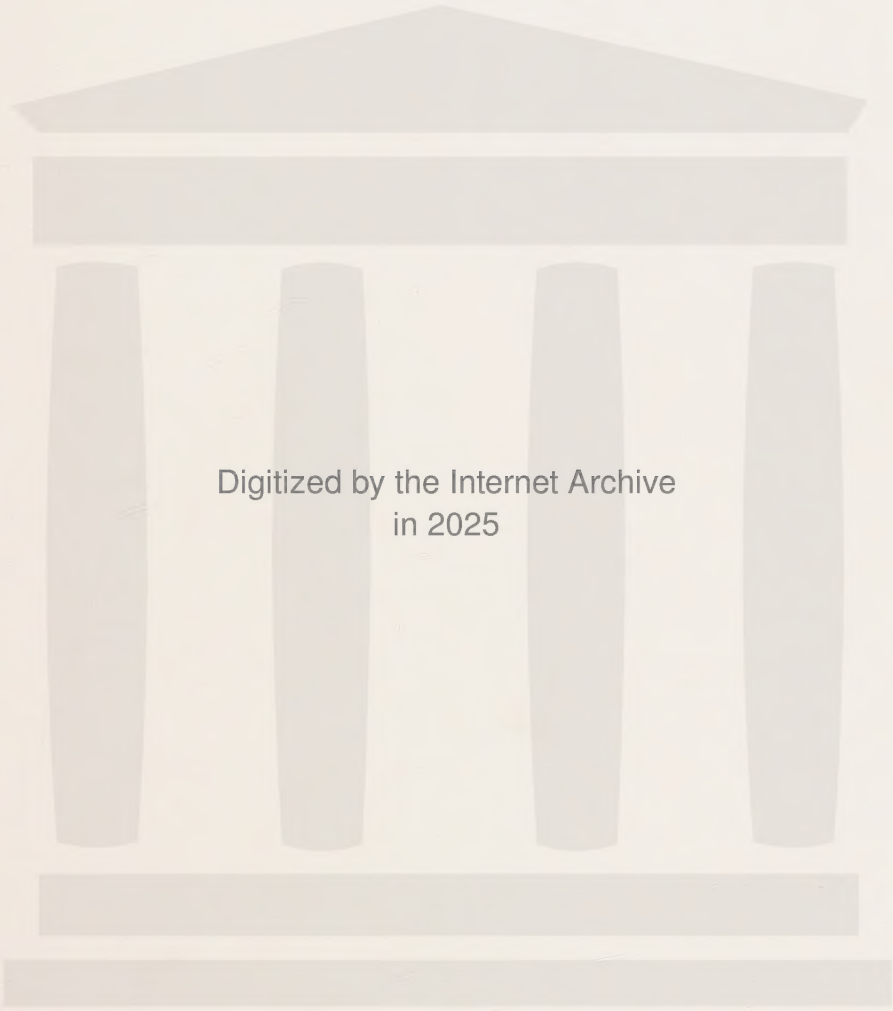
Published
June 1952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A35

THE KENT INCORPORATED SOCIETY
FOR PROMOTING EXPERIMENTS IN
HORTICULTURE

ANNUAL REPORT

(THIRTY-NINTH YEAR)

1951

EAST MALLING
RESEARCH STATION

Near MAIDSTONE

KENT

1st October, 1950 to 30th September, 1951

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The correct abbreviation of the title of this Report is :—
Rep. E. Malling Res. Sta. for 1951 (1952).

PRINTED IN GREAT BRITAIN BY HEADLEY BROTHERS LTD
109 KINGSWAY LONDON WC2 AND ASHFORD KENT

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† Appointed under special grant from Agricultural Research Council.
‡ Transferred to the Scottish Horticultural Research Institute, April, 1951.

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Book-keeper: P. R. Wood.

Director's Personal Secretary: Miss L. M. Read. (*Resigned September*, 1951.)

Clerical Staff: Miss J. M. Coy, Miss J. D. Martin (*Resigned November*, 1950), Miss J. M. Parsons (*Resigned November*, 1950), Miss L. Sherratt, Miss P. M. Rayfield, Miss R. M. Wickham, Miss I. Cross, Mrs. F. J. Fitness, Miss D. M. Ansell (*Resigned June*, 1951), Miss M. E. Wedgbury (*Resigned July*, 1951), Miss P. H. Westacott (*Resigned December*, 1950), Miss D. Clegg (*Resigned October*, 1950), Miss I. Bell, Miss P. Rayfield, Miss J. Bates (*Resigned March*, 1951), Miss K. D. Apps, Miss D. L. Card (*Appointed October*, 1950), Miss B. J. Gosling (*Appointed November*, 1950), Miss C. R. Westwood (*Appointed January*, 1951), Miss P. Hughes (*Appointed July*, 1951), Miss P. M. Lincoln (*Appointed August*, 1951), Miss G. E. Wright (*Appointed August*, 1951), Miss V. Theobald (*Appointed August*, 1951).

VISITORS.

Tours of the Station are arranged by appointment on Tuesday and Thursday afternoons. Visitors with special interests are received by appointment on the mornings of these days and may then join the general tour later if they wish. Wednesdays and Fridays are reserved for visiting research workers who also should make an appointment to ensure that a useful programme for the visit can be prepared.

All visitors wishing to see the work of the Station should go to the Enquiry Office at the Research Laboratories.

Visitors coming by road should take the turning to East Malling, opposite " The Bull ", Larkfield, on the main London-Maidstone road. The entrance gate to the Research Station is on the left, opposite the " King and Queen " in East Malling.

Bus Service : From Maidstone by the Maidstone and District Motor Services Limited, every 20 minutes from Maidstone to East Malling.

Passenger Station : East Malling Halt (British Railways, Southern Region).

Goods Station: Aylesford (British Railways, Southern Region).

Correspondence : All correspondence should be addressed to the East Malling Research Station, near Maidstone, Kent.

Telephone : Maidstone 7294 (3 lines). *Telegrams :* Research, East Malling.

THE COMMONWEALTH BUREAU OF HORTICULTURE AND PLANTATION CROPS

Accommodated at Bradbourne, the Administrative Headquarters of the East Malling Research Station.

STAFF.

Director : D. Akenhead, O.B.E., M.A.(Oxon), B.Sc.Agric.(Lond.).

Consultant Director : F. R. Tubbs, M.Sc.(Lond.), Ph.D.(Lond.), D.I.C., A.R.C.S., F.L.S.

Assistant Director : G. K. Argles, Dip.Hort.(Wye), A.I.C.T.A.

Assistants : H. Wormald, D.Sc.(Lond.), A.R.C.S., D.I.C.
V. H. Goldschmidt, Ph.D.(Berlin).
Miss P. J. Rowe-Dutton, B.Sc.Hort.(Lond.).
Mrs. E. Ulyatt, Dip.Hort.(Eisgrub.)

Clerical Staff : Miss M. B. Rogers, Miss M. M. Durling, Miss J. E. Morrison, Miss J. Cranham (*Appointed June,* 1951).

NATIONAL AGRICULTURAL ADVISORY SERVICE

Accommodated at Bradbourne, the Administrative Headquarters of the East Malling Research Station.

Telephone : Maidstone 7278.

PROVINCIAL ADVISORY OFFICER—FRUIT, SOUTH-EASTERN PROVINCE
W. G. Kent, N.D.H.

Clerical Assistant : Mrs. J. E. Waldren. (*Appointed January,* 1951.)

FOREWORD

In presenting the Annual Research Report for the year 1st October, 1950, to 30th September, 195 attention is drawn to the Administrative Report, published in April, in which many additional deta of the life and work of the Station will be found.

The working of the Experimental Farm is described in Part I of this Report, while in Part reference is made to some of the numerous investigations in progress in each Section. As the Scienti Staff now numbers, in round figures, 40 Scientific Officers, 30 Experimental Officers and 50 Assistan (Scientific), it will be appreciated that the necessarily brief Sectional Reports can provide only a outline of the work of the Sections.

The number of research reports in Part III has increased considerably in the last few year Reference to individual papers would be invidious, but attention may be drawn both to the text the Amos Memorial Lecture, delivered by our Chairman, Mr. T. Neame, at East Malling on 22r November before a record audience of some 400, and to the paper from the Scottish Raspber Investigation by Dr. C. A. Wood. This Investigation, sponsored by the Agricultural Researc Council, administered by East Malling, and directed for eight years by Dr. R. V. Harris, has mo than justified the hopes entertained at its inception, and we now wish every success to the ne Scottish Horticultural Research Institute, in which it was incorporated on 1st April, 1951.

Growers' Bulletins, to be found in Part IV, are rather fewer than usual this year; son fluctuation in number from year to year is unavoidable.

This Foreword provides opportunity to return thanks to those, too numerous to mentic individually, who have assisted the progress of the Station and of its work during the year. Mo detailed, but still necessarily incomplete, acknowledgements are made in the Administrative Repor

The frontispiece depicts the staff of the Commonwealth Bureau of Horticulture and Plantati Crops, of which Sir Ronald Hatton was the first Director. Founded in 1929, it has lived and work from the beginning in the closest touch with the staff of East Malling Research Station, a policy whi has been happily continued under its present Director, Mr. D. Akenhead.

The retirement of our Secretary, Mr. C. T. Royle, after 18 years' wholehearted work for t Station, is a very real loss which is mitigated only by our knowledge that he will continue to vi the Station frequently. On pages 15-16 will be found an appreciation of his diverse and great valued services to the Station, to the Staff, and to the Association.

C. T. ROYLE

Secretary, East Malling Research Station, 1933-51, at his desk at Bradbourne.

[*face p. 15*

C.T.R.

When a senior research worker retires, it is a fairly simple matter to assess his contribution to the Station's work, basing the account on his scientific papers and other writings. But the Secretary of a Research Institute has no published reports to show and, indeed, to appreciate the amount and importance of his work, one must dig into the voluminous administrative correspondence, committee minutes and the like in the Station's archives that are mercifully hidden from all but a few. Even there no record will be found of the innumerable small happenings that complicate his daily life.

Royle came to East Malling at a time when the adolescent Research Station had just reached maturity and, in 1933, was preparing to celebrate its 21st birthday with the visit of H.R.H. the Duke of York, later His Majesty King George VI, in the spring of the following year. One of his first major tasks was the organization of that event.

At the time that he took his seat in the Secretary's Office, in what is now a chemical laboratory in the Manwaring Building, the Station was passing through one of the recurring financial crises with which he was destined to become all too familiar subsequently. The short-lived Empire Marketing Board had come to an untimely end, leaving much of the Station's work and several of its staff in a state of suspense that was only terminated when, in April, 1935, the Ministry of Agriculture finally amalgamated the old E.M.B. grant with what was known as the ' A ' grant. Of necessity, Royle's first responsibility has always been with the detail of the Station's finances ; a comparison of the research grants in 1934 (£15,000) and in 1951 (over £100,000) gives some indication of how his duties in that respect have grown. It is worth noting that our present Chairman, who joined the Executive Committee in the same year that Royle was appointed, was a year later, as Finance Chairman, to become closely associated with him.

Royle has always maintained the principle that it is the task of the ' Office ' to serve the Station's research and he has always resisted any proposals that might lead to an unnecessarily large administrative staff. When he first came he had a staff of six to serve the needs of a research team of 32, apart from the farm ; now, although the research team has grown four-fold, his staff still numbers only 18, on whom fall many new duties then unthought of. This is something of an achievement in view of present day tendencies ; it has been attained by insisting that each member of his staff shall be an expert at his or her particular job, and be capable of carrying it out without the assistance of an army of untried juniors.

Throughout his 18 years, Royle has had a dual role to fill—on the one hand that of the faithful servant of the Chairman, the Director and the Governing Body, and, on the other, as the administrative guide, philosopher and friend of the staff. In the first capacity the Membership Scheme, that rock which has sustained the Station's well-being through so many ups and downs, has always been one of his first concerns. Under his fostering care the ' Membership ', since 1947 the E.M.R.S. Association, has more than doubled its strength ; further, many of our members are also our personal friends, as witness their response to a recent appeal for the funds to build a sports pavilion, and this is in no small measure due to Royle's constant care for their interests.

Yearly, it has been the Secretary's job to prepare the material for that part of our Administrative Report that details the activities of the Governing Body and Executive Committee. Although his name is seldom mentioned, this is actually a report of his work and it is worth remembering some of the major events chronicled.

The day-to-day problems of a growing staff continued and increased as the years went by, and in pre-war days we may recall such exceptional events as the revision of the Articles of Association, the purchase of new land by the Trustees, the laying of main drainage and the fire in the N.F.U. Building. Nor must we forget the financial headaches of running the experimental farm on a bank overdraft that reached £10,000 in 1940.

During this period much work went into plans for new laboratory space. But later these were temporarily put aside, for in 1938 the Station took the biggest step forward in its history by acquiring the Bradbourne estate. How much work Royle put in at that time and during the next few years in the purchase of the estate, adaptation of the house for our needs and negotiations and appeals, finally completely successful by 1941, for the necessary finances, only Sir Ronald Hatton knows. As a reminder of the time, however, there hangs in the Secretary's office the draft advertisement for the sale piecemeal of Bradbourne House and land, with only the date missing, that Royle brought home triumphantly from the Auctioneer's office after the completion of the sale. Since that day he has always had a soft spot for Bradbourne, even when the ceiling above him threatened to fall on his

devoted head. He rapidly absorbed its history and its atmosphere, while his daily inspection of th stream will long be a source of affectionate amusement to those who saw, and sometimes accompanied him at it.

In January, 1940, the 'Office' moved to Bradbourne and, in September, the first Annua General Meeting was held there while the Battle of Britain raged overhead. On that occasion i must have been somewhat difficult for the Secretary to concentrate on the business before the meeting

The war brought many new tasks, quite apart from the flood of Government orders, returns an the like that affected every member of the farming community. (Among them Royle will not readil forget, we think, either the arable foreman's cow or the Director's pig.) A.R.P. had to be organized and measures taken to protect research buildings and Bradbourne House in case of fire, and here w should remind ourselves that throughout the war Royle served three nights a week as a responsibl member of the volunteer night staff in the Maidstone A.R.P. Control Centre. And when the Statio duly received its quota of bombs, it was, of course, the Secretary's job to see that the mess was cleare up, the damage assessed and compensation duly received. Visitors were evacuated from London t continue their work in our laboratories, and each brought his own financial problem ; while the fac that we were living in a 'restricted area', if it had its compensations, also entailed difficulties.

By 1942, one of the less unpleasant effects of war was beginning to show in the reduction an eventual elimination of the bank overdraft, as the result of the increased value of our farm produce However, even this was not without its headaches, for to distribute fairly our surplus rootstocks an other nursery material in face of the large demand was no easy task. By 1944 we were sending ou a million rootstocks and could easily have distributed double that number.

With the termination of hostilities, the real expansion of the Station's work began and with it th ever-growing problems of laboratory and glasshouse accommodation and staff housing. Until recently when the new virus-houses were erected, it was possible to do little to increase laboratory accommoda tion, save to make better use of existing space and add the 'prefabricated' staff canteen, though even these were not achieved without many administrative difficulties. Before the war the Statio was responsible for four living houses, occupied by the Director, the Caretaker, the Guide Demonstrato and one member of the research staff. By 1951 homes had been found for some 50 members of th farm and research staffs in 33 houses, all of which come under the care of the administration. T mention but a few of them, there were the 12 cottages built for the farm staff, the Grange, Cour Lodge, Park Farm House and last, but by no means least, the eight houses in Church Fields completed a year ago. Each has brought its own problems either in building, adaptation or repairs. It is a tribute to Royle's tact and skill that all the schemes in connection therewith have been successfully carried out to the satisfaction of the various Ministries and other authorities concerned.

Sir Ronald Hatton retired in 1948, to be succeeded by Dr. F. R. Tubbs six months later. The Station owes much to Royle's services during the transitional period, for development proceeded unchecked, largely owing to his unremitting labours. When he gets time to sit back and put his fee up (an unlikely event, anyhow) he may well look back on the edifice he has helped to build and be satisfied ; though he may possibly chuckle when he thinks how similar the problems of his successo will be to those he found here 18 years ago.

Royle owes much of his success at East Malling to three outstanding qualities, his integrity, his attention to detail and his sense of humour. To him there is a right and a wrong way to meet each difficulty ; he will never have any truck with those expedients with which so many members o society to-day justify a somewhat doubtful course of action.

Every member of staff, who has known him, will testify to the patience and understanding with which 'C.T.R.' has listened to and attempted to solve his or her particular problem, be it superannua tion, P.A.Y.E., salary (even the mysteries of provincial differentiation), or many another even more personal matter ; none has proved too big or too small for his attention.

Yet, time and again, his unfailing ability to see the humorous side of his difficulties must have sustained his own sense of proportion, as it certainly helped those who were in close contact with him

The news that he was to retire has come as a shock to many of us, and, while we do not grudge him his hard-earned leisure, we wish he could have stayed with us a little longer. But since the di is cast he and Mrs. Royle take with them the good wishes of us all for a happy retirement, and many years in which to enjoy it.

Since this appreciation was written, we are able to add that the Executive Committee have made Royle an Honorary Member of the East Malling Research Station Association in recognition of his long and valuable service. We may, therefore, look forward to seeing him here regularly on Open Days and, we hope, many other occasions as well.

T.N.H.

Part I

*THE EXPERIMENTAL FARM**

By F. H. VILLIERS, with contributions from T. V. DIXON and M. M. MACNEILL

Those who read the Administrative Report for the year 1950-51 will note the large difference between the cost of the experimental farm and the receipts from sales of produce. Although, despite rising costs all round, the former has been maintained practically the same for the past three years, the returns have steadily fallen.

Many factors have contributed to this result. In the first place the area capable of bearing saleable crops has gradually decreased, partly because bearing orchards no longer of experimental value have been grubbed and partly because much land is now devoted to intensive experiments that can never be expected to yield a profitable return. This is, of course, one of the functions of the farm ; there are, however, other causes over which we have little control. It is true that, in 1951, we had no damaging frosts and that, on the whole, we harvested good crops of most fruits ; but all through the notes that follow the adverse effects on many crops, both arable and fruit, of the very wet winter and spring followed by a showery, sunless summer, will be clearly seen.

The effect on the size and quality of apples was particularly bad. War-time markets, wherein any fruit was saleable, are gone for good and only the best fruit is now marketable. As many fruit growers will know, 1951 was not a season in which high quality fruit was easy to produce.

From blossom to harvest the season was one of the latest for many years. Apples (e.g. Bramley's Seedling) were not in full bloom until 20th May, while we could not start picking Early Rivers cherries until the 27th June, a full three weeks later than in 1950. Again, strawberry picking did not start until the 19th June—continuing until the end of July—and we were still picking raspberries in mid-August. Finally, the last of the apples were not harvested until 1st November. In other years we have blessed a late season, because it generally meant the avoidance of spring frost and a quick blossoming period. This year there was less cause to rejoice, for the consequent shortages and gluts of fruit during August and September had a very adverse effect on prices and returns.

Experimental orchards.—Top fruits.

Apples.—During the season 12,768 bushels of apples (40 lb. to a bushel) were marketed or put into store, but some 900 bushels more that were harvested were too small to be worth sending to market. Thus the total crop was 13,668 bushels, the heaviest since the mature Bramley's Seedlings in Kiln Field were grubbed in the autumn of 1949. The younger plantations on Church Fields West and at Larkfield, established since the war, are now in their seventh year and made a useful contribution to the total, many of the trees of Cox, Worcester and Jonathan carrying over 3 bushels of excellent fruit. As has already been mentioned, the quality of the rest of the apple crop was not nearly as good as in 1950. Shortage of labour made it difficult to do as much fruit thinning as we should have liked, but even on varieties which do not normally require thinning, such as Bramley's Seedling, fruit size was poor. The lack of sun during the summer and autumn, combined with a late attack of red spider, resulted in a very poor colour on some of the later dessert varieties, particularly Cox's Orange Pippin, of which the crop, 2,309 bushels, was the largest since the record year of 1947. The young trees in the rootstock and pruning trials in the Larkfield plantation bore heavy crops for their age, and the size and appearance of the fruit was good. The large trees of Cox's Orange Pippin on M.XII in the manurial trial on Church Fields also cropped well ; this is the second good crop running. Although these trees are over 20 years old they have borne little fruit until quite recently ; it now seems, however, that they have at last reached full bearing. The 64 trees averaged almost 9 bushels per tree of picked fruit this year. These trees would now comfortably occupy a 30-foot square plant.

Worcester Pearmain also did well for the seventh successive year and a total of 3,163 bushels was marketed. In the rootstock trial on Great East, where the fruit was thinned to singles and the crop 'stuck on' with an anti-drop spray, thus facilitating later harvesting, the quality of the apples was excellent, both as regards size and colour. In the cover crop trial on Kiln Field, however, where no

* —for the calendar year 1951.

thinning was done, much of the fruit was under $2\frac{1}{4}$ inches in diameter and thus of little value. The Lane's Prince Albert on Great East were drastically spur-thinned at pruning time and bore a useful crop of good quality fruit, but the Bramley's Seedling on the same field, though abundant, were small.

Pears.—There are now only about $1\frac{1}{2}$ acres of mature pears on the Station, chiefly Conference and Dr. Jules Guyot. These, together with two young plantations of Williams' Bon Chrétien and Conference in double-working trials on Egham Field, yielded a total of 378 bushels (48 lb. to a bushel) in 1951. This, though much better than the 1950 crop (200 bushels), was less than it should have been because of conditions at blossom time that caused poor pollination.

Cherries.—The total cherry crop harvested in 1951 was 1,104 halves (24 lb. to a half sieve). This is the smallest crop for several years and cold weather at blossom time was again responsible. However, the fruits, though few, were of excellent quality, particularly the Early Rivers which were marketed in 12 lb. chips and, although 832 halves less were sold, the total cash return for cherries was only £200 less than in 1950.

The trees in the variety collection on Egham Field, many of which are later blossoming, were not nearly so badly affected as those in the rootstock trial on Church Fields. The crop of Early Rivers, for example, on Church Fields was only about half what it should have been, whereas there were full crops of some varieties on Egham.

Plums.—The plum crop at East Malling was apparently unaffected by the cold weather at blossom time. All varieties cropped well, particularly Victoria, some of the trees of which had to be thinned.

The gage plum variety and rootstock trials on Deadman Field carried their best crops to date and altogether a total of 2,529 halves (28 lb. to a half sieve) was harvested, compared with only 1,239 halves in 1950. Denniston's Superb, Oullins Golden Gage and Ontario were again the heaviest croppers and several other varieties yielded between 3 and 4 halves per tree. Marketing all these different varieties so that they reached the consumer in good condition was again a problem ; their tendency to split, mark and rot makes the handling of these high quality dessert plums difficult. However, just over 800 12 lb. chips of gages were marketed at an average price of approximately 8d. per lb., which compares very favourably with good quality Victorias which were difficult to sell at $2\frac{1}{2}$d. per pound, and much more than covered the extra cost involved in more careful handling and the provision of non-returnable containers.

The trees in the Gage Variety Collection, many of which are on Myrobalan B rootstock, have now become very large and at 14 years old from the bud are much too thick at 15 feet square. Cultivations have become difficult and ripening very uneven ; many trees are growing right up out of reach, instead of spreading outwards as they come into cropping. As a result of this, and to enable us to study the natural habit of the trees, this plantation was thinned out in the autumn.

Small fruits.

All soft fruits, except black currants, cropped well in 1951. There was plenty of young bearing wood and plenty of blossom on the currants, but, on some plots where detailed records were made, 60 per cent of the flowers failed to set and the yield was only just over 18 cwt. per acre. Repeated crop failures on Merryweather seem to indicate that the site is too exposed for most varieties of black currants, and it has been decided to grub most of the bushes this autumn ; it is hoped to plant further black currant trials in a more sheltered position as soon as a suitable piece of land becomes available.

As mentioned in last year's Report, a new trial of loganberries was planted in December, 1950 ; the plants grew well during the summer, the thorny loganberry plants making between 6 feet and 8 feet of cane growth, and the thornless plants somewhat less. The permanent wirework will be erected in January, 1952, and the first canes trained ; these should bear a small crop the following July.

The raspberry crop was just over 8 tons, the heaviest for some years, averaging just under 4 tons per acre. As with all our experiments, our raspberry trials include some varieties and some treatments which are not expected to give maximum yields and it is interesting to record, therefore, that one plot of Malling Landmark in our cultural trials on Upper Grub yielded at the rate of almost 8 tons per acre.

The strawberry crop was also much larger than for some years, almost 6 tons of fruit being marketed. The heaviest crop came from one half-acre piece of Auchincruive Climax in Egham Field, which yielded 1 cwt. short of 3 tons. The seven other small scattered patches of mixed varieties (approximately 2 acres in all) yielded 3 tons between them.

Fruit marketing.

Fruit quality was not nearly as good in 1951 as it had been in 1950, and, as a result, the financial returns from our apple crop were considerably less. The keen competition from imported Continental fruit, which the home apple crop now has to meet, makes it more than ever important to concentrate

on quality. Large Fancy grade fruit sold reasonably well, but only slightly smaller or poorer coloured fruit made quite unremunerative prices. The new cold store completed in September, 1950, was of great value and enabled us to keep many of our smaller Worcester Pearmain off the market at the peak of the season, and to market them in an orderly fashion later when the price rose slightly. After the Worcester Pearmain were cleared, this store was filled with Bramley's Seedling and Lane's Prince Albert and sealed up for gas storage until the New Year. The apples were graded for quality and sized, but, because of the high cost, it was decided to take the risk of not using oil wraps. Our second store was filled with Cox's Orange Pippin for cold storage until Christmas and the third store with Laxton's Superb, Barnack Beauty, Jonathan, Allington Pippin and small amounts of other keeping varieties. All our better quality fruit was marketed under the Ministry of Agriculture 'Recommended' grades and was favourably commented on in the markets.

Fresh plantings and grubbings.

During the winter 1951-52 most of our fresh plantings were again destined for trials initiated by one or other of the pathology sections. In the autumn of 1951, on the Bradbourne land, a further small area of plums and $1\frac{1}{3}$ acres of pears were planted for Entomology trials; about $\frac{1}{2}$ acre of young trees and rootstocks for virus work; and a similar area of cherries, plums and pears for intensive experiments in connection with the testing of new insecticides, etc. Approximately $\frac{1}{3}$ acre of Lord Lambourne with Cox's Orange Pippin pollinators was planted in Newgates field for virus studies and, in Egham Field, a small plot of plums for silver leaf studies and one of cherries and plums for bacterial canker trials. In Great East Field, the site of the former 'Pruning Plot' has been allocated to plant-breeding trials; and part has been planted with new seedling apples as cordons and part with a collection of the newer varieties and some of the more interesting older ones as dwarf pyramids for plant-breeding purposes. The remainder of the land has been planted with M.VII rootstocks, which it is intended to run up to form frameworks on which the more promising of the new seedlings can be grafted as they become available.

The site of the old 'Golding' hop garden at Bradbourne has been planted with numerous varieties of all kinds of fruit trees and bushes for future frost investigations, this being the lowest land on the Station.

The last of our cropping hops, 1·3 acres of Brewers Gold and Bullion, on Egham Field, were grubbed in October, 1951, as these varieties are now established in sufficient quantities at Wye. In addition to other fruit plots already mentioned, some of the Mazzard cherries in the cherry variety collection in Egham Field, no longer required, were grubbed, as were also the Dr. Jules Guyot pears on Caucasian Quince rootstocks, most of which had proved incompatible, on Plot 27. On Great East, a further eight rows of apple cordons, trials on which had been completed, and some other trained trees of which there are now much better examples in Bradbourne Gardens, were also cleared. Parts of the original Lane's Prince Albert apple rootstock trial, now 33 years old, had become very overcrowded in recent years and it was reluctantly decided that some of the Grenadier pollinators, most of which were on vigorous rootstocks, must be removed. It must be remembered that, when these were planted little was known of their vigour potentialities, so all were placed at the same distance, originally 15 feet square. To ensure future pollination some of the Lane's will be frameworked. The variety to be used is Howgate Wonder.

Routine spray programme.

Once again there was no major change in the routine farm spray programme for the 1951 season. All peaches, plums, black currants and raspberries were sprayed with 5 per cent tar oil before Christmas. No cherries were winter-sprayed this year as the entomologists did not consider there were sufficient pests present to justify this now very expensive wash being applied. The apples were again sprayed with a 4 per cent DNOC wash containing 2·4 per cent of dinitro-ortho-cresol, and pears with a 5 per cent wash of the same material. The pears were sprayed during the latter half of February and the DNOC application to apples was finished on 21st March. The weather during these two months was atrocious and made efficient spraying very difficult. This may perhaps have contributed to the bad attack of red spider that developed later in the season. More probably, however, the mites spread from certain trees under special trials that could not be summer-sprayed.

The spray programme for Apple Scab control followed very closely that carried out in 1950. As many of the apple plantations as possible were sprayed three times before blossoming with lime-sulphur and three times after blossoming with a fungicide varied to suit the variety; thus most plantations had six scab sprays. In a difficult season like 1951, in order to avoid long intervals between applications and to keep the growing fruit and foliage covered with fungicide, at least six sprays seem necessary to get good control. DDT at 0·1 per cent was again included in the green cluster

scab spray, not as a routine measure this year, but only where the numbers of caterpillar and capsid bug eggs seemed to warrant its use. Apple Sawfly was controlled by using benzene hexachloride in the first post-blossom scab spray, but this year only 1 lb. of a 50 per cent preparation was used instead of 2 lb. as in 1950. Codling moth larvae were not controlled very successfully ; Cox's Orange Pippin plantations had only one lead spray in mid-June, but most other varieties were sprayed twice with mercurated lead arsenate, once at the fruitlet stage in early June and again during the last week of the month. Probably a further spray still later would have given better control.

Cherries were sprayed during leaf fall with Bordeaux mixture at 10 : 15 : 100 and again at the white bud stage with Bordeaux at reduced strength, to which 0·1 per cent DDT was added to control caterpillar, which it did most effectively. Mature plums and damsons were sprayed with 2 lb. of derris and spreader at the cot split stage against sawfly, and young plums received, in addition, two copper sprays, one in mid-May and one in mid-June for the control of bacteriosis. There has been little evidence of any serious damage from cane spot on raspberries at the Research Station for some years ; accordingly raspberry plots were only sprayed three times during the summer, twice with benzene hexachloride against Cane Midge and once with derris against Raspberry Beetle. Similarly, black currants were not sprayed against midge this year, as the damage caused by this insect in fruiting plantations seems more apparent than real ; also the two DDT sprays used in previous years may have interfered to some extent with pollination where varieties are inter-mixed as they are here. Strawberries were dusted, as necessary, with sulphur against mildew and once with DDT and sulphur to control Strawberry Weevil. Fruiting beds were sprayed with parathion six weeks before picking and non-fruiting beds with schradan to control aphid and minimize the spread of virus. The commonly available formulation of this latter insecticide does not appear to keep very well. Our first application with material retained from the previous season did no good, but later spraying with fresh material worked well.

Arable Crops.

The area under arable crops in 1951 was reduced to 122 acres. Approximately 15½ acres had been taken up by fresh trials and additions to the new stoolbeds on Park Farm but 2½ acres were added, chiefly by grubbing part of the old stoolbeds in Ditton Field ; thus there were 13 acres less than in 1950. As with fruit crops, the year was a difficult and disappointing one. Prolonged heavy rains made all sowing and planting a laborious business and conditions at harvest time were little better.

Potatoes.—Only 17¼ acres of potatoes were grown, 6 acres of Stormont Dawn and the remainder Majestic. Most of the potatoes came off the heavier land, some on ground only cleared of nursery material in January, where, though planting was delayed until the first week of May, it was impossible to get the fine deep tilth necessary for potatoes. This late planting in cloddy ground greatly reduced the crop, which only averaged approximately 8 tons per acre as compared with an average of 12 tons the previous season. Potato Blight was again troublesome, but the bulk of the crop was marketed early, at or soon after lifting time, so that little deterioration occurred.

Peas.—In common with other growers, we found that, in this season, early varieties of canning peas yielded much better than the later ones. Generally the early sorts yield anything up to ½ ton per acre less than the main crops, but this year our 8½ acres of Surprise yielded 15¾ tons, or 38 cwt. per acre, whereas 7 acres of Lincoln only averaged 24 cwt. per acre. The Lincolns were grown between rows of maiden trees. We have found this a very useful crop for this purpose ; the manurial requirements of the peas do not conflict with those of the trees, nor do the peas impoverish the ground as would brassicas or most other crops.

Cereals.—Both wheat and barley suffered considerably from the bad weather. Twenty-four acres of Plumage Archer barley were grown. Of this, 14 acres were December sown but, although on apparently free draining soil, much of it was winter-killed by waterlogging and the yield was only 3 qrs. per acre. The remaining 10 acres were spring sown in March under poor conditions, but did surprisingly well, averaging 7 qrs. per acre. Both pieces were damaged to some extent at harvest time and, though sold for malting, the samples were not the best. Wheat was less disappointing, yielding 5½ qrs. per acre overall and was harvested in good condition in spite of the weather. Forty-eight quarters of Squarehead 13/4 were threshed early and sold for seed ; 70 qrs. of Holdfast were threshed later and sold in December. Of 26 acres of one-year ley, 19 acres were made into hay and 7 acres into silage. The hay was all cured in big Scotch cocks and thus secured in good condition. The silage was made this year, for the first time, with a Buck rake which was found to be of the greatest assistance and will soon pay for itself in the saving of hand labour. Approximately 5 acres of kale and mangolds were grown for winter food for our bullocks, and grew to perfection in the damp weather. The mangolds, popularly supposed to need plenty of sun to mature them properly, did

particularly well. The variety grown has always been Kirshes Ideal and regularly yields over 30 tons per acre fresh weight and has a higher dry matter content than any other mangold.

Forty-nine Devon steers were kept during the winter of 1950-51. They did not thrive quite as well as in previous years, as the continuous rain made it hard to keep the yards dry and comfortable. However, they sold reasonably well and left some 500 tons of good dung behind them.

F.H.V.

Experimental nurseries.

Though the general demand for planting material has declined considerably, as most nurserymen will know to their cost, the nursery section here at East Malling has been more than usually busy during the past 12 months preparing material for experimental purposes. In addition to the more familiar rootstock, pruning and variety trials, wherein the trees are widely spaced and stay for many years, there are now a lot of small, intensive experimental plots which require comparatively large numbers of trees. These plots are often quite short-lived and the trees are usually closely planted dwarf pyramids or cordons, so that there is a continual heavy demand for nursery material.

Just over 9,000 one-year-old trees were in the nursery during 1951, very few of which were available for distribution after experimental requirements had been satisfied. Smaller quantities of soft fruit plants and strawberry runners were also produced mainly for experimental purposes. Growing conditions throughout the summer were, on the whole, good, though the frequent rains made weed control difficult and the ground was exceptionally wet at lifting time in the autumn. However, almost all trees and bushes were lifted mechanically and harvesting was not unduly delayed, being finished just after Christmas. The lifter used was the one described in last year's Report and we wonder now how ever we managed without it.

Pests and diseases gave little trouble and routine sprayings, as recommended in the Ministry of Agriculture Bulletin on fruit tree raising, kept the nursery clean. It should be pointed out that parathion is now used for the control of aphids in preference to nicotine, as it is more persistent.

Rootstocks were again distributed this year, but their routine propagation from now onwards will be on a greatly reduced scale. The old stoolbed on Ditton Fields was finally grubbed at the end of the year and the new stoolbed to the west will be sufficient to meet experimental needs for standard varieties of rootstocks. None of the new Woolly Aphid resistant rootstocks have yet been distributed to members or to the trade, but we hope that a few of these new rootstocks may be available before long.

Amos Black black currant bushes and Early Worcester and Late Orange graft wood were sent out again in 1950-51, as far as the limited supplies available would allow ; it is hoped to have rather more Amos Black bushes available in 1952-53.

T.V.D.

Experimental glasshouses.

Visitors to the Station will have observed that the area under glass has greatly increased in recent years ; indeed, including the necessary space for plunging pots, etc., outside, the greenhouses now cover practically the whole of the old Plots 1 and 2 on Great East Field, about 1½ acres in all. Now that the new virus houses are completed and have been in use for a season, it seems worthwhile to give a description of the whole range and the purposes for which the various houses are used.

In 1939 there were four houses—the propagation, pomology, pathology and small virus houses —and one insectary. In 1946, three 'dedutchables' were purchased as a temporary measure until more permanent houses could be built. Later the large insectary and potting shed were built, and in November, 1950, the two new virus houses were completed.

The propagation house, rebuilt in 1950, is 40 feet long and 11 feet wide. It is equipped with built-in frames, some of which have hot water pipes beneath them to give bottom heat ; in addition, one double and one single frame are wired for electric heating. Both are thermostatically controlled to maintain a fairly even temperature a few degrees above the house temperature. This house is used primarily for the rooting of leaves, cuttings, and walnut and seedling grafts. A small area at the south end is partitioned off for breeding woolly aphids for experimental purposes.

The pomology house, also rebuilt since the war, is of standard design with a few modifications. It is 92 feet long and 24 feet wide, and is divided into two large and two small sections ; three sections can be kept insect proof. The large sections are used to accommodate trees for plant breeding experiments, and the others contain strawberries for various purposes. Fruit trees used for frost investigations are also accommodated on the floor during spring and summer.

The pathology house has two main sections, one 48 feet by 24 feet which is sub-divided into one large and two small sections, each of which has a concrete floor. These have been used for the production of hops and to give various varieties of apple and pear shelter during and immediately after

inoculation with strains of Apple and Pear Scab. The second section is 11 feet wide and 48 feet long, and is sub-divided into three smaller sections, two of which have internal frames. On both sides of this portion external teak frames are used to accommodate apple, peach, apricot, plum and cherry seedlings. The stone fruits are stratified and then sown in boxes. A few other plants for experimental uses and seedling graft material are also kept in these frames. A succession of tomatoes, variety Ailsa Craig, for use in pathology investigations, are produced throughout the year, and various plants, such as alpine strawberries, cucumbers and brassicas, are grown as required in the narrow portion of this house.

The three houses just mentioned may be heated by hot water from a Robin Hood sectional boiler ; the heat supplied to any one house or section of a house can be regulated to some extent.

The propagation and pomology houses have slat type wooden blinds fixed at or near the ridge of each house. These blinds are heavy and wear and tear on rope tends to be high, but they have a much longer life than cloth blinds, and probably keep the temperature lower in view of the air space between the blind and the glass. The narrower part of the pathology house has scrim cloth blinds which roll up to the ridge. The remaining portion of this house is only partly covered with wooden blinds.

The small virus house of four equal sections is 40 feet long and 10 feet wide. The door opening to the outside has an inner door with gauze instead of glass and the top and bottom ventilators are fitted with gauze to make the house insect proof. This house contains strawberries for virus tests by grafting, also plants collected over a period of years and maintained for use as required.

There are 13 insectaries, each 10 feet long and 10 feet wide, in two blocks of four and nine, each one having cloth blinds. This type of house is designed to give conditions approximately the same as those outside, at the same time being insect proof and affording some protection from wind and rain. The roofs are glazed, but the walls and partitions are of phosphor bronze gauze. The smaller of the two blocks contains rootstocks and seedlings for Woolly Aphid resistance tests, and also plums and apples for red spider work. The large block contains pears, apples, currants, gooseberries, and numerous wild and cultivated plants for use as alternative hosts for different species of aphid, as well as strawberries for eelworm and pathology experiments.

The 'dedutchables' are used to house apple seedlings for Fruit Tree Red Spider Mite investigations, apple trees and raspberries for spray damage experiments, and rootstocks, the roots of which are kept in a nutrient solution mist.

There are two gauze houses that are still being used for the propagation of virus tested varieties of strawberries. These gauze houses are modified 'dedutchables' where all the side 'lights', and a number of those on the roof, have been replaced by gauze to prevent the entry of aphids that would infect the plants.

The main potting shed, which was built recently, has a rubber covered bench 36 feet long, with racks inside for the smaller sizes of pot and bays outside for the larger pots. Provision is made for the sterilizing of soil, pots and boxes, steam being supplied from a vertical dairy type boiler.

The two new virus houses are 112 feet long and 30 feet wide, one being 17 feet to the ridge and the other 18 feet 6 inches. The former is divided into 13 sections, the latter into 10. The houses are designed with the primary object of keeping them insect proof ; with this in mind there are a few modifications to the traditional type of glasshouse. The glass is supported mainly by aluminium alloy glazing bars, and is bedded in a mastic ; the panes do not overlap each other, but are separated by a cross bar, also of aluminium alloy. Air is drawn through an oil screen to remove all solid matter, including insects, and then passes through a chamber where it can be moistened with warm or cool water to increase the humidity in the house, if required. Two fans, which may be operated independently, run at constant speeds, but the air supply may be regulated by means of two dampers. The air is supplied to the various sections in each house through a duct running underneath the concrete floor in the middle of each house, from which small openings guide the air into each section. The warm air escapes near the apex through gauze.

Both houses can be heated by low pressure steam from a central boiler to the north of the houses. Each house has three thermostats which give a wide range of temperature, and a further control may be effected by means of valves, which are common to all sections. These thermostats operate a motorized valve which is opened or closed automatically ; when the valve is closed the pressure increases at the boiler and the pressurestat stops the motor supplying fuel and air, until the pressure falls. The boiler is equipped with an automatic stoker which has three speeds, the air supply being adjusted to suit the quantity of fuel supplied to the firebox. The condensed steam returns by gravity to a tank in the boiler house and is used again ; this feature, in conjunction with the stoker and the thermostats, reduces fuel consumption to a minimum. When the boiler is used to supply steam for sterilizing boxes and pots and partially sterilizing soil for composts, the water evaporated is replaced automatically from the main supply through a ball valve. Due to the hardness of the water (about

200 p.p.m. calcium carbonate) it is treated to reduce or prevent scale inside the boiler and pipes.

A potting shed with a rubber covered potting bench and provision for sterilizing pots and boxes, and partially sterilizing soil, is conveniently placed between the two houses and connected to both by a corridor.

Scrim cloth blinds are fitted at the eaves of both houses. This is contrary to the normal practice and necessitates the use of weights to roll up the blinds.

The plant material in the smaller house consists almost entirely of strawberries, for the production of runners of various varieties, and *Fragaria vesca*, which is used as a virus indicator, in fairly large numbers. Plants received from various sources are potted and kept until required for virus tests. The large section at the north end has four brick bays which are used to produce runners as required. The larger house contains hops in the north end ; plums, apples, F.12/1 cherry rootstocks, apricots, morello cherries and peaches for fruit tree virus work, with a few red and black currants and gooseberries, are housed in the south end sections.

The number of plants and trees in pots ranging from 2 inch to 12 inch, under glass and outside, is over 12,500 ; there are also a few 18-inch pots plunged outside. During the spring of 1951 about 4,000 seedlings were produced, and sowings of various types have been made throughout the year as required. Apart from the John Innes composts, which are used for the majority of material grown, sand and vermiculite, and vermiculite alone, have been used. Various cuttings have been rooted. Hop shoots, inserted in a mixture of sand and peat, were rooted as a quick means of increasing the number of plants from a particular parent.

The spaces between and around the various buildings are used as plunging grounds for varieties of apple, as well as pears, plums, cherries, raspberries, red and black currants, apple seedlings, apple rootstocks, and hops, which are brought under glass as required. A small area near the new virus houses has been used to plant hops for use in conjunction with those under glass.

During the winter of 1950-51 three more 'dedutchable' houses were added to house, mostly for the blossoming period, material being prepared for exhibition during the Festival of Britain. For this purpose strawberries, raspberries, black currants and apples were brought to fruiting stage before being taken to the South Bank. Many more plants, all in pots, had to be raised than were actually exhibited ; the space within these three houses being inadequate, room had to be found at vital periods in one or other of the permanent houses. Most of the potted trees were plunged outside during the summer. Despite the provision of shelter, however, the weather was against us and it was very difficult to produce creditable plants at the various times they were required. The three 'dedutchable' houses have now been acquired permanently.

M.M.M.

Part II

GENERAL REVIEW OF RESEARCH WORK

WITH LISTS OF PAPERS PUBLISHED DURING THE YEAR

I. POMOLOGY

By W. S. ROGERS

Papers on the work of the Pomology Section, published during the year, included a major study on stock-scion incompatibility (E351) a general review of research on rootstocks (M12) and preliminary recommendations on the method of frost control by water sprinkling (see page 197).

All the older trials have been maintained, and continue to yield useful information. The 26 acres of younger apple plantations are increasing in interest as the trees approach maturity. A comprehensive soil management trial has been begun on 3½ acres of these plantations and studies on root environment have been intensified.

Other experiments, on both top and small fruits, have been continued and expanded ; in fact, the work is probably greater in extent and variety than ever before. Details of new developments are included below.

Tree fruits.

It is not feasible to report at length the progress of all the long-term experiments in progress and details of those referred to in recent Annual Reports have been omitted.

Rootstocks.

The younger apple rootstock trials, consisting of the Woolly Aphid-resistant series and the M.IX Crosses, continue to grow well. Certain of the M.IX Crosses have now been selected, on the basis of their nursery and field performance, for raising in rather larger quantity. Many dwarfing rootstocks have been rejected, owing to serious suckering in the field, but a wide range of promising new rootstocks remains available. Records of Apple Scab have been made, in collaboration with the Plant Pathology Section, on unsprayed trees of Cox's Orange Pippin on some of these rootstocks to see if any of them render the scion variety less susceptible to this disease.

In the gage plum rootstock trial, now 11 years old, trees on Myrobalan B maintained their lead in crop yield.

The search for dwarfing or semi-dwarfing sweet cherry rootstocks has been continued.

In the trial of clonal pear rootstocks worked with Williams' Bon Chrétien and Conference, now in its third year from planting, interesting differences in tree habit and precocity are already becoming apparent.

Incompatibility.

Some trees in the trial of double-worked pears planted in the winter of 1949-50 have shown symptoms of incompatibility. Unions of one- and two-year-old trees of the same combinations are being examined to see if there is a correlation between symptoms of incompatibility and the structure of the union.

Two field trials of double-worked plum trees on Myrobalan B rootstock have been planted. Their behaviour will be recorded and examined in relation to the anatomical structure of the unions of young plants of the same combinations.

Trees formed of various plum rootstocks grafted together have been planted to study the degree of compatibility between rootstock types.

Full accounts were published (E351) of experiments designed to study the relationship between certain features of the growth and structure of fruit plants and their compatibility when grafted together. The structure of the graft union, the condition of the inner bark above and below the

union, and the distribution of starch in different parts of the tree were found to be related to compatibility. The problem of incompatibility in a wide range of plants is discussed in the paper.

Another paper (E350) described the reaction of two compatible graft components to the introduction of a third variety as rootstock, as intermediate, or as a bark ring.

Histological investigations.

The structure of the phloem in the roots of young quince trees grafted with incompatible pear scions was examined, and found to show degrees of abnormality varying from complete collapse of the tissue to excessive cell division without proper differentiation. The degree of abnormality will be examined in relation to the behaviour of individual trees.

Possible causes of the failure of the graft union between President plum and Myrobalan B rootstock, following top working with Victoria, have been investigated in fifteen-year-old trees. A condition known as stem-pitting was found in the stem of the Myrobalan rootstock, and the starch gradients were reversed in the incompatible Victoria/President/Myrobalan B compared with trees of Victoria/Victoria/Myrobalan B. The structure of the phloem in the roots of the incompatible trees was abnormal. A paper on the subject is in preparation.

The distribution and length of fibres in the stems of apple and plum trees have been examined in order to study the relationship between these features and the mechanical strength of the trees. The length of fibres has been measured in the stems of certain apple varieties liable to branch breakage.

Some five-year-old seedlings from Pershore plum trees have borne flowers and fruit, showing that their juvenile period is relatively short. Nearly one-third of the 600 seedlings bore flowers and 50 plants set fruit, some very freely. Features of the stem structure of the plants that flowered have been recorded and will be examined in relation to the rooting of cuttings from these plants. Observations have also been made on the structure of a series of apple, pear and plum stems used for cuttings and the results examined in relation to the number of cuttings that rooted. The anatomical changes associated with age of plant are being examined in one-year stems from young and old plants of plum rootstocks.

A collection of *Prunus* species and varieties has been maintained and further observations made on stem and root structure. The stem and root structure of the commonly used plum rootstocks is being studied in relation to the known effect of these rootstocks on the growth and fruiting of scion varieties.

Roots from Cox and Worcester trees on certain rootstocks growing on three soil series in Kent have been preserved and will be used to study the effect of soil and variety on root structure. The bark percentage of the roots has already been measured.

A paper on the origin and structure of bridge tissues in ring-grafted apple stems is in the press. Attention is drawn to the fact that ring grafts often break and bridges arise from the tissues underlying the bark ring.

During the year anatomical characteristics have been used to assist in the identification of rootstocks and of scion roots, in forecasting the probable effect of rootstocks on scion growth, in the recognition of rubbery wood, and in the study of a dieback that was prevalent on apple trees in the spring of 1951.

Work on the mycorrhiza associated with apple and with strawberry has been continued. Reproductive stages of the fungus have been discovered and will be used in an attempt to infect sterile seedlings.

New plantations.

The Churchfields (loam) and Larkfield (sand) plantations, which include the new rootstock, pruning and variety trials, are now six years old from planting. They again cropped well, though not quite so heavily as in 1950. The fruit on Larkfield was early ripening and highly coloured.

A long-term soil management trial has been started on one section of the Churchfields West plantation (see under Soil Management).

On a section of the Larkfield plantation in which growth had been poor and variable, a small scale factorial experiment has been started to study the effects on tree growth of deblossoming, irrigation and mulching with farmyard manure. In a closely related trial, the effects of nutrient injections are being studied, in collaboration with the Biochemistry Section.

Propagation.

Cutting experiments have continued in collaboration with the Physiology Section. The studies of the effect of mode of propagation and nutrition of the parent plant have been widened to include rootstock influence. A preliminary survey of leaf and bud propagation of apple rootstocks has been

made. A paper on grafting apple seedlings in the cotyledon stage has been published (E345). Further nursery technique trials have been concerned with cotyledon-stage grafting in the open and the use of plastic strips for tying newly inserted buds.

A further series of rootstock-scion compatibility tests have been made with pears, plums and cherries. Scions of pear and cherry from France and Australia are being tested for compatibility alongside scions from local sources. The rootstock collection has been extended by new introductions and many specimens have been distributed to research and educational centres at home and overseas.

Double working.

The field trials with pears and cherries have been maintained and additional nursery trials have been started. A report on the double worked Victoria/President/Myrobalan B plum trees is being prepared.

Soil management.

In the older trials, the comparison of grass with cultivation, superimposed on the cherry rootstock trial, shows interesting trends in the first 10 years' crop figures.

The modified short-term ley experiment has been continued. The Biochemistry Section is carrying out leaf analyses on the trees of this trial and also those of the long-term cover crop trial on Larkfield.

A new large scale trial has been started on part of the Churchfields West plantation (see under New plantations). The trial is in two parts. In the first, clean cultivation, a grass and clover sward, a permanent straw mulch and cultivation plus autumn weeds are compared, the variety being Laxton's Superb apple on M.II. All three treatments receive two levels of nitrogen fertilizer. The grass mixture used in this part of the trial was S23 Perennial rye grass with Kent wild white clover. The second part of the trial compares this mixture with five others, namely, Chewings fescue with wild white clover, Timothy S50 with Kent wild white clover, a natural sward, Kent wild white clover alone and Subterranean clover. The last two were chosen to give legume-rich swards, and the other three as less vigorous than the standard. The trees in this case are Fortune on M.II.

The pilot trial, comprising 11 soil management treatments since 1943 on Cox's Orange Pippin and Worcester Pearmain on M.IX, has now served its purpose and will be concluded.

Inorganic fertilizers.

The two inorganic manurial trials on apples were continued. The classical NPK trial is now 21 years old.

Weedkillers.

The investigation on the use of three weedkiller treatments in an apple plantation has completed its second season. See also Strawberries and Raspberries.

Soil studies.

Soil samples have been taken on many of the experimental plots. Determinations of organic carbon and of nitrogen have been made on samples from some of the soil management and manurial trials, and other analyses have been kindly made by the N.A.A.S.

The policy is being continued of giving special attention to the physical characteristics of orchard soils. Work has been carried out on aeration and on structure, but the emphasis has been on soil moisture studies in connection with the field experiments. Soil moisture tensiometers have been widely used, and their data have been supplemented by the oven-drying method. Soil moisture values throughout the summer have been compared with the soil moisture deficit values calculated from meteorological data by the methods of Penman and Smith. The moisture deficit concept has been found to give a useful approach in these studies.

Further information has been obtained on soil and air temperatures in connection with the straw mulch investigations on soft fruit. In order to elucidate some of the problems involved in the study of moisture and temperature relationships, trials have been laid down in the open, in which measurements are made under straw mulch, grass sward and cultivated soil.

A detailed survey of the soil types and sub-types of the whole Research Station, by Mr. B. S. Furneaux, is in progress.

Restoration of soil uniformity.

The experiment in restoration of the uniformity of the soil after the grubbing of mature apple trees has been continued. After the mangold crop of 1950, the ground was sown in spring 1951 to a

two-year-ley consisting of Cocksfoot, Italian Rye Grass and Broad Red Clover. No obvious differences due to tree position have appeared in the sward. (See also under Statistics and Biochemistry.)

Pruning.

In the trials of tree shape and method of pruning in relation to biennial bearing of apples, the regulated trees continue to crop heavily and maintain extension growth, but the Laxton's Superb trees are strongly biennial.

Experiments on widening the crotch angles of plum trees by the use of growth substances have been continued. The bush peaches in a pruning trial at Bradbourne made even stronger growth than in 1950. Most branches had a dead tip, both on trees pruned during the winter and those left unpruned. These were all removed in late May. A curious abnormality, resembling "ghost-blossoms" in apples, appeared in almost all the blossoms. The petals were small and imperfectly expanded, and the blossoms failed to set fruit. Some branches have been lost, apparently from Bacterial Canker.

Fruit thinning.

The apple thinning trial, using the leaf count method, begun in 1945, has been concluded and a report is in preparation.

Biennial bearing.

Studies on biennial bearing were limited by the unfortunate absence of Miss M. H. E. Davies on sick leave throughout the growing season. Routine records on existing trials were maintained.

Frost-damage investigations.

The protection of plants against frost by sprinkling with water has been the main project. Field investigations were carried out during natural winter and early spring frosts, using as test plants, potato, runner bean and strawberry plants and fruit trees, all in pots, forced on in the greenhouse. Tests were made of various types of sprinkler in relation to water distribution, performance under frosty conditions, the effect on plant temperature at different distances from the sprinkler, the effect of different rates of precipitation and the cumulative effect of an array of sprinklers. Automatic control of the sprinklers by a thermostat was successfully achieved in several small trials.

Two arrays of small rotary sprinklers covering $\frac{3}{4}$ acre, and a large rotary rainer, were tested on a grass ley during early spring frosts. The sprinklers were moved to an orchard at Collier Street, by courtesy of Mr. E. Manwaring, for the apple blossom season ; no critical air frosts having occurred during this period, the essential field tests on mature trees remain to be made. The new trailer caravan, fitted as a mobile instrument room, has proved very successful.

Laboratory tests included studies of intermittent sprinkling and of different rates of precipitation. A demonstration of frost control by water sprinkling was arranged for the 1951 Festival Chelsea Show of the Royal Horticultural Society, using plants in a Coldrator refrigeration cabinet kindly loaned by the International Refrigerator Company. In this cabinet, strawberry and potato plants were protected by sprinkling in temperatures as low as 18° F.—the severest test so far. A short review of the practical possibilities of sprinkling as a frost control measure appears on page 197.

A paper was published (E344) on the effect of certain growth-regulating substances upon frost-damaged flowers. The most promising substances were tested further in 1951. None of the substances used stimulated either recovery of critically frost-damaged flowers or parthenocarpic fruit development.

Trials were carried out with maleic hydrazide sprays to test their possible delaying effect on blossoming of raspberries in the current season and of apples in the following season. Some effect was observed in the raspberry. In the apple, some check to growth was observed. The effect on blossoming will be seen in 1952.

Varietal resistance studies were continued. Some early damage in the field, probably due to a frost on the night of 14th-15th April, when the temperature fell to 28° F., was noted on Bramley's Seedling apple and on some pears and black currants. Studies of eight pear and eight black currant varieties were made. The pear Glou Morceau was almost undamaged, while Durondeau had 39 per cent of its blossoms damaged, but set well. Among currants, the most forward were generally the most damaged.

Tests in the cold chamber were made of five new East Malling apple varieties compared with Cox's Orange Pippin, of five black currant varieties, and cut racemes of eight varieties grown in the field, of eleven strawberry varieties, and of six raspberry varieties in pots, together with cut racemes of eleven varieties grown in the field. No outstandingly resistant varieties were found.

The Laine fog-producing apparatus for protection from frost was inspected at the Horticultural Research Station, Wädenswil, Switzerland, by courtesy of the Director, Dr. Kobel.

The results of an earlier study of the effects of hessian and netting anti-frost screens and of brick walls were published (E343). Hessian was found to give a 4° or 5° F. rise in air temperature when hung over wall-trained trees at night.

A paper on frost damage to fruit plants, read at the International Congress of Refrigeration, is now in the press.

Intensive fruit culture.

The apple and pear dwarf pyramid pruning trials and the Worcester cordon leader tipping trial have been completed.

Varieties and classification.

All the apricots in the collection at Bradbourne except Early Cape, Shipley and Croughton have been grubbed to make room for the peach variety and rootstock trial. Trees have been budded for a new nursery trial.

The apple, pear, plum and cherry collections have been maintained. Systematic descriptions of the new apple rootstocks have been commenced.

In the gage and plum variety collection, now 14 years from the bud, Denniston's Superb bore 200 lb. per tree ; Oullins Golden Gage 170 lb. ; Laxton's Gage 150 lb.; Ontario 130 lb.; Late Orange 120 lb.; and Comte d'Althans, Early Transparent, Jefferson, Victoria and Warwickshire Drooper 100 lb. per tree.

Breeding.

The work of testing new apple and pear seedlings, selected as possible new varieties of merit, has been continued. Of about 300 apple seedlings bred from Woolly Aphid resistant parents to provide resistant scion varieties, some 5 per cent have proved very highly resistant after two seasons' artificial infestation, and are being prepared for fruiting trials.

A study of late-flowering apple varieties has been begun, and crosses between certain varieties have been made.

Studies on the effect of different pollen parents on the size, weight and other characters of Cox's Orange Pippin apples have been continued. King of the Pippins, Miller's Seedling and Worcester Pearmain were used as the pollinating varieties (see page 62).

Small fruits.

Trials of strawberries, raspberries, black currants and loganberries have been continued.

Variety and strain trials.

Strawberries.—The 1951 strain and variety trials included Royal Sovereign and Auchincruive Climax (two strains each), Mme. Lefebvre and Perle de Prague (three strains each), Huxley, Early Cambridge, Jucunda and several minor varieties. Climax and Perle de Prague were the heaviest croppers. Jucunda has given a very poor performance.

Raspberries.—The two cropping trials bore their fifth and third crops respectively. Seedling T was first in both trials, with about 5 tons per acre ; W, Y and 51/47 all produced over 4 tons per acre, and Norfolk Giant about 3¾ tons per acre (considerably more than it has ever before produced at East Malling). Malling Promise was fifth and Malling Exploit seventh in the older trial, and Promise third in the younger. Of the 17 varieties in the two trials (three are in both) only two fell below 3 tons per acre, a figure which a few years ago was regarded as near the maximum.

The heavy cropping of Seedling T bears out early indications ; but it is unlikely that the variety will be suitable for present planting, its fruit being hardly large or firm enough for present day requirements. The fruit of Seedling 51/47 is in most respects satisfactory.

Two short rows of Malling Landmark yielded the heaviest crop ever recorded at East Malling for any variety, equivalent to almost 7 tons per acre.

Loganberries.—A trial of the Malling clonal Loganberry, which has thorns, and the Thornless Loganberry, selected in the U.S.A. and imported to this country some years ago, has been planted. The plants will be trained by two methods ; one that is satisfactory, but rather laborious, and one that is designed to save labour. Provision is made in this trial for soil management treatments to be superimposed at a later date.

Black Currants.—In the black currant variety trial Cotswold Cross carried the heaviest crop, followed by Wellington XXX.

Propagation.

Strawberries.—Runner beds were again planted only with gauze-house material and the single-parent blocks at 9 feet square yielded between 50 and 100 good runners per parent. A limited number of runners surplus to research requirements was distributed for Special Stock nurseries.

Breeding.

Black Currants.—Several seedlings which have proved to be very late in ripening have been selected from a cross between Amos Black and Baldwin. Further hybrids between the black currant and other species of Ribes have been obtained. Aberrant forms, possibly tetraploids, resulting from the colchicine treatment of young seedlings, are under observation.

Raspberries.—The raspberries Malling Promise and Malling Exploit, bred by Mr. N. H. Grubb, received the Award of Merit of the Royal Horticultural Society in July, 1951, for both commercial and private garden culture.

The latest batch of seedlings (Families 77 to 90) germinated in 1950, grew well and bore a little fruit, but not enough to show their value. One family, a second generation self, is more vigorous than any similar family so far raised.

Cultural measures.

Strawberries.—A paper on spacing trials and matted systems has been published (E340), showing that large increases of yield can be gained by using matted *rows* instead of spaced single rows, although matted *beds* are not recommended on account of risk of drought effects. Similar results were obtained in the 1951 trials. A cultural trial of Climax, cropping for the first time in its second year, yielded at the rate of $4\frac{3}{4}$ tons per acre.

A further trial of burning-over after cropping, compared with cutting and removing the leaves and with removal of the straw only, is in progress.

Significant crop increases were obtained from irrigation in two trials in 1951.

A further weedkiller trial has been carried out on an area of Auchincruive Climax in its second year. For March application, 2, 4-dinitro-6-secondary butyl phenol and isopropyl N-phenyl carbamate were tried ; the latter was found to check the strawberry plants considerably. As in 1950, the strawberry plants were not harmed by an application of the sodium salt of 2, 4-dichlorophenoxyacetic acid.

Raspberries.—The pilot experiment on the use of weedkillers has been continued.

A large-scale replicated trial comparing permanent straw mulch with cultivation, at two levels of nitrogen, has been started. The effects of mulching are very encouraging.

Black Currants.—The two main manurial trials have been concluded, apart from final growth measurements and soil analyses. The trials suggest that straw mulches may have important effects on soil moisture relations.

In the trial comparing post-cropping pruning with normal winter pruning, the earlier pruned bushes have again borne the higher crop. Spring and summer nitrogen applications are also compared in this trial.

Walnuts.

Many trees carried good crops again this year, although a high proportion of nuts showed imperfect ripening of the shells.

In the variety trial, the interplanted loganberries were grubbed last winter, and the plot was sown with a grass and clover mixture in May. The trees, now in their tenth year from planting, are growing well, and in general carried good crops for their age and size.

Horticultural meteorology.

Routine meteorological observations and special records of air temperatures, soil moisture, and wind in relation to various experiments, have been maintained. Cup counter anemometers have been erected in some Kent orchards at different elevations and a progress report on the observations has been prepared (see page 93).

Observations at the Crop Weather Station at Throwley, a sub-station to East Malling, have been maintained. After much delay, this Station is now fully equipped with instruments.

The Meteorological Office has again kindly provided special frost warnings during certain periods of the year.

Publications During the Year.

In relation to Tree Fruits.

Greenham, D. W. P. **Orchard soil management.** Worcs. Agric. Chron., 1951, **19**, 123-39; Grower, 1950, **34**, 1267-8 (Under different title) (E341).

Villiers, F. H. and Dixon, T. V. **Mechanical aids to nursery work.** Rep. E. Malling Res. Sta. for 1950 (1951), 201-2 (E342).

Rogers, W. S. and Beakbane, A. B. **The effect of netting and hessian anti-frost screens and of brick walls on air temperatures.** Rep. E. Malling Res. Sta. for 1950 (1951), 60-4 (E343).

Modlibowska, I. **The effect of certain growth-promoting substances upon frost-damaged apple flowers.** Rep. E. Malling Res. Sta. for 1950 (1951), 65-70 (E344).

Garner, R. J. **The grafting of very young apple seedlings.** Rep. E. Malling Res. Sta. for 1950 (1951), 71-5 (E345).

Preston, A. P. and Barlow, H. W. B. **The use of growth substances to widen crotch angles.** Rep. E. Malling Res. Sta. for 1950 (1951), 76-9 (E346).

Glenn, E. M. **Walnut varieties.** Rep. E. Malling Res. Sta. for 1950 (1951),80-6 (E347).

Mosse, B. and Herrero, J. **Studies on incompatibility between some pear and quince grafts.** J. hort. Sci., 1951, **26**, 238-45 (E350).

Herrero, J. **Studies of compatible and incompatible graft combinations with special reference to hardy fruit trees.** J. hort. Sci., 1951, **26**, 186-237 (E351).

Rogers, W. S. **Protection from spring and autumn frosts by continuous water sprinkling.** Grower, 1951, **36**, 626-8 (E352).

Glenn, E. M. **Grafting walnuts, some methods used in France.** Fruit Year Book, 1951-52, 91-3 (E353).

Hoblyn, T. N. **Research on fruit tree rootstocks.** Brit. Agric. Bull., 1950, **3**, 103-11 (M12) and Rep. E. Malling Res. Sta. for 1950 (1951), 193-200.

In relation to Small Fruits.

Rogers, W. S. and Modlibowska, I. **Strawberry cultivation studies. III. Spaced and matted systems.** J. hort. Sci., 1950, **26**, 47-59 (E340).

Reid, R. D., Grubb, N. H., Spinks, G. T. and Wood, C. A. **The breeding of varieties of fruit.** Fruit Year Book, 1951-52, 98-112 (E354).

Hops.

Beard, F. H. **The classification of hop varieties according to their ease of picking.** Rep. E. Malling Res. Sta. for 1950 (1951), 187-9 (B69).

—— **Propagation trials with hops. VII. Number and size of sets produced from strap-cuts of certain varieties.** Rep. E. Malling Res. Sta. for 1950 (1951), 190-2 (B70).

General.

Preston, A. P. **Weather conditions during 1950.** Rep. E. Malling Res. Sta. for 1950 (1951), 90-2 (E349).

Villiers, F. H. (with contr. by T. V. Dixon). **The Experimental Farm.** Rep. E. Malling Res. Sta. for 1950 (1951), 15-20 (E348).

II. STATISTICS AND RECORDS

By T. N. HOBLYN and S. C. PEARCE

Many changes in staff have resulted in the Section's work being restricted in nearly all its aspects, so emphasis has been placed on bringing existing research projects to a tidy conclusion rather than on starting new ones. Nevertheless, all general activities have been maintained and, in addition, 12 joint meetings have been held in five of the other research Sections to describe the work of the Statistics Section and to discuss ways in which it can co-operate even more fully in the work of the Station.

A major change has been the enlargement of the Section and its acceptance of responsibility for the statistical aspects of fruit trials on the N.A.A.S. Experimental Horticulture Stations. Co-operation with outside bodies has continued, notably with the N.A.A.S. in general, Wye College and the Scottish Horticultural Research Institute.

Routine work.

The provision of assistance in the design of experiments and in the filing, analysis and interpretation of data continues to absorb a large part of the Section's time.

East Malling.

The Record Office has received its most thorough stocktaking since the war, but otherwise filing has proceeded without incident. The preparation of summaries of records and the supply of maps and plans have been continued. In the latter connection, the large scale detailed map of the whole Research Station, prepared by the Ministry of Agriculture's Survey Branch, will be invaluable.

Advice on trial design has been given throughout the year. Greater use than formerly is being made of statistical design and analysis for laboratory trials. For field trials, more complicated designs are being recommended so as to economize land and labour, provision being made, wherever possible, for the addition of further treatments later.

More than half of the 267 routine statistical analyses (i.e. those not arising from the Section's research projects) were carried out for members of the Pomology Section. The analysis of variance remains by far the most generally used method of interpreting data.

N.A.A.S. Experimental Horticulture Stations.

Up to date the Fruit Working Party, representing the Research Stations interested, have considered programmes of experiments for four Stations : Luddington, Warwickshire ; Efford, near Lymington, Hampshire ; Stockbridge House, Cawood, Yorkshire and Fairfield, Kirkham, Lancashire.

Of these, the Luddington programme is the most advanced and plans have been prepared for experiments planted in 1950-51 and to be planted in 1951-52. Among these is an apple calibration trial in which use has been made of one of the newest tile designs (see page 105). No fruit experiments at the other Stations will be planted until 1952-53, except N.F.T. small fruit trials at Stockbridge House; but preliminary plans have been made, as they must be, well in advance, so that the supply of plant material can be arranged for.

Statistical Research.

Research in progress includes studies of statistical techniques, of sampling methods and of plant variation.

Methods of experimental design and interpretation.

Further work has been done on designs that can make use of outside trees in the experimental plantation. These designs can also be used to add a new set of treatments to an existing trial in randomized blocks.

Methods have been devised for laying out calibration trials with three varieties (see page 105).

A report has been published on the accuracy of comparison of certain pairs of treatments in split-plot designs (M11).

Biometrics (plant variation and sampling).

Most of the work on optimum plot size has now been published, namely, that on unguarded plots of cacao (M13), of apples (M14) and of strawberries (M16). No further work has been done along these lines, but a start has been made in trying to find a mathematical relationship connecting the crops, etc., of neighbouring trees. Also, a study has been begun to investigate the relative accuracies of main plot and sub-plot comparisons in split-plot designs.

Work on calibrating measurements of strawberry plants and on the interpretation of spread records has also been reported (M16).

A sampling method for size of cherries has been described and published (M15).

Work has been started on the estimation by eye of the crops of individual apple and cherry trees, such a method being needed for trials on commercial plantations.

A study of the estimation of tree weight from trunk girth is described on page 101. This work is continuing.

Field trials.

The apple uniformity trial has now completed its first year's growth. The experiment on restoring the uniformity of land being carried out in collaboration with the Pomology Section and now in its second year, was sown with a two-year ley in April ; no further residual effects of tree position have been observed, although they had been so marked in the mangold crop of 1950.

PUBLICATIONS DURING THE YEAR.

(See also M12 under Pomology).

TAYLOR, J. **The comparison of pairs of treatments in split-plot experiments.** Biometrika, 1950, **37,** 443-4 (M11).

PEARCE, S. C. and THOM, J. M. S. **A study of plot size with Nigerian Estate Cacao.** J. hort. Sci., 1951, **26,** 261-7 (M13).

——— ——— **The variability of apple trees. II. The optimum size for unguarded plots.** J. hort. Sci., 1951, **26,** 98-108 (M14).

TAYLOR, J. **The estimation of fruit size of cherries by sampling methods.** Rep. E. Malling Res. Sta. for 1950 (1951), 93-9 (M15).

——— **Statistical studies on strawberry crop and vigour measurements.** Rep. E. Malling Res. Sta. for 1950 (1951), 100-7 (M16).

III. PLANT PHYSIOLOGY

By M. C. VYVYAN

The intimate collaboration between the Plant Physiology Section and the staff of the Research Institute of Plant Physiology under Professor F. G. Gregory has continued, and the following report includes reference to the work of the latter carried out at East Malling.

Vegetative propagation.

Experiments with hardwood stem cuttings have continued in collaboration with the Pomology Section. The principle studies were (i) the behaviour of cuttings from different cultural sources when planted at East Malling (in loam and lake soils) and at Boskoop, Holland, (in collaboration with the Nursery Research Station, Boskoop) ; (ii) the winter and summer storage of cuttings before planting ; (iii) the effect of height of water table, using the terraces of Bradbourne island ; (iv) the influence of growth substances on rooting and establishment, including a further experiment with certain substituted phenoxy acids. Papers have been published on the concentrated dip method of treating cuttings with growth substances (F63) and on the use of these substances in rootstock propagation (F60).

Physiology of growth and form in fruit trees.

The stock on stock trees in the experiment on the reciprocal influence of scion and stock in apple trees have made satisfactory growth. Samples were taken in March, June and September, and a further sample will be taken in October. Material for analysis was taken by Biochemistry at the September sampling. Additional detailed growth records were taken when the trees were snagged back, and when the snags were finally removed.

More detailed and frequent growth records have been made on two ' typical trees ' selected on each of the 120 plots. Despite routine protection, mildew, aphids, red spider and the tortrices *Spilonota ocellana* and *Adoxophyes orana*, gave some trouble ; in particular *Spilonota* caused considerable damage to the terminal buds of the maiden shoots. Malling II scions were especially affected.

The willow cuttings, used in the experiment on the mechanism of the response to stem pruning, have been dug up, and the weights of their roots, main stems and branches determined. Unfortunately there were many casualties under the more severe treatments. The results have not as yet been analysed.

In collaboration with the Pomology Section, a report on the use of growth substances to widen crotch angles has been published (E346), and a further experiment on the control of crotch angles has been carried out on maiden trees of Victoria plum and Laxton's Superb apple. Treatment of the tip of the cut-back shoot with indole-3-butyric acid gave satisfactory results with plum, but not with apple. In order to avoid using large numbers of maiden trees in expansion of this work, an experiment was performed on layer-bed shoots of the plum rootstocks Myrobalan B and Brompton, cut back in mid-season. Branches grew out very quickly, and interim results show that both stocks form sensitive test objects for work on crotch angle control. New lines to be followed up next season were indicated.

Four experiments were performed (with the help of temporary recording staff) on the influence of individual leaves on the growth of young internodes of Crab C stoolbed shoots. Preliminary examination of the results shows that there is a large positive effect of the tip on the elongation of the internode, and a smaller effect of an individual leaf on the internode below it, particularly in the absence of the tip. There is some suggestion that the lower leaves may exert an inhibiting influence on the young internodes above them.

A technique is being evolved for growing trees in soilless culture, by applying nutrient solutions to the roots in the form of a fine mist. The main object is to eliminate, when necessary, variability due to soil conditions when examining the growth rates of trees of different varietal composition or under different pruning treatments.

Abscission and the shedding of fruits, blossoms and leaves.

A review of results of experiments on the use of growth substances for the control of fruit drop has been published (F59), and reports have been made on the effect of season and date of spraying on

the control of June drop in Cox's Orange Pippin (F62), and on the effect of rain on the control of pre-harvest drop in Sunset apples (F64). The results of the 1949 and 1950 experiments on June drop in Bramley's Seedling, and on pre-harvest drop in that variety and in Cox's Orange Pippin have been examined and summarized (see pages 108, 112).

A further experiment has been carried out to determine the effect of the time of application of napthalene-acetic acid upon blossom and fruit shedding in Cox's Orange Pippin. The results were somewhat marred by an outbreak of the disorder known as 'Ghost-flower', but they provided further evidence of the importance of the date of spraying. Any reduction in drop that resulted from the earlier sprays was offset by a period of severe shedding later on. Reduction of June drop by the later sprays was not counteracted in this manner. Sprays at intermediate occasions gave intermediate results.

In order to obtain further information upon the mechanism of abscission, observations have been made, and some small scale experiments have been carried out, on dead leaves retained during the winter by certain normally deciduous trees, such as Beech when grown as a hedge, and coppiced Hornbeam.

Experiments on the possible control of the 'shattering' of hops, that often results from machine-picking, by substances that inhibit abscission, gave negative results, but the problem will be examined again next season.

In response to a request from the Botany Department of Manchester University, a plant extract prepared there has been assayed for its ability to inhibit abscission. The substance was tried at seven concentrations on Crab C petioles, and compared with a standard solution of NAA and with indoleacetic acid, by a technique devised some time back, but not hitherto used on a large scale. The technique appears to be satisfactory, but the experiment is not yet complete.

Attempts to follow the course of abscission in sections of plum pedicels have been continued. Some success has been obtained, but the technique is not sufficiently developed as yet for use in quantitative experiments.

Blossom thinning by sprays.

A final examination of the effect of NAA on pollen germination and tube growth indicates that it is unlikely that the blossom thinning properties of an NAA spray are due to a direct effect on fertilization. A simple and rapid technique for growing pollen in culture was evolved.

Hormone relations in fruit trees.

A survey of ether extractible auxin in shoots of apple and plum from the bud stage, covering one season's growth, the winter dormant period and a portion of the second season's growth has now been completed, with parallel observations on the inhibitor factor. In addition, a more detailed examination has been made of the critical period when growth is renewed in spring ; a similar examination is now in progress of another phase between cessation of active extension growth and leaf fall.

The effect of the oxygen content of the atmosphere on rate of transport of auxin has been studied in stem sections of Crab C. Under anaerobic conditions, transport of auxin did not take place ; increased oxygen concentrations up to 5 per cent gave increased transport rates, the rate at 5 per cent being not far short of that obtained in air.

A comparison of the rate of transport in two apple and two plum stocks (Crab C, M.IX ; Brompton, Myrobalan B) gave no clearly significant differences.

Fruit-splitting in plums.

A single experiment was carried out this year, but the variety used, Utility, though considered a bad splitter, was unaffected this season.

Spray damage.

The spinning disc spray machine, built for the spray damage programme last year, has provided a suitable means of comparing the efficiencies of wetting agents, and the work has developed in close collaboration with the Plant Protective Chemistry Section.

The relative efficiencies of different wetters, when acting at various concentrations on the hairy undersurface of the raspberry leaf, have been examined by a new method, but no correlation has yet been found between efficiency and any specific physical property of the solution. The effect of the concentration of the wetter upon the volume of spray required to wet a leaf completely has also been examined (see page 119), and its effect on the damage caused by a spray solution has been determined. Using ammonium thiocyanate as the most convenient damaging agent and the fresh/dry weight ratio

as the most consistent index of percentage damage, a linear relation has been demonstrated between the logarithm of the concentration of the agent and the probit of the percentage damage (see page 115).

Publications During the Year.

Vyvyan, M. C. **Use of growth regulators to control the shedding of fruits.** Proc. IInd Intern. Congress of Crop Protection, 1951 (F59).

Hatcher, E. S. J. **The use and effect of plant growth regulators in rootstock propagation.** Proc. IInd Intern. Congress of Crop Protection, 1951 (F60).

Vyvyan, M. C. and Trowell, G. F. **Use of sprays to control fruit drop. VII. Effect of season and date of spraying on control of June drop in Cox's Orange Pippin.** Rep. E. Malling Res. Sta. for 1950 (1951), 111-5 (F62).

Hatcher, E. S. J. and Garner, R. J. **Aspects of rootstock propagation. II. The development of the concentrated dip method of treating hardwood cuttings with growth substances.** Rep. E. Malling Res. Sta. for 1950 (1951), 116-21 (F63).

Barlow, H. W. B. **Use of sprays to control fruit drop. VI. Rain and the control of pre-harvest drop in Sunset apples.** Rep. E. Malling Res. Sta. for 1950 (1951), 108-10 (F64).

IV. BIOCHEMISTRY

By W. A. ROACH

In view of the progress in analytical methods reported last year, this year the Section has turned much of its energies to evolving a method for growing small fruit trees under controlled conditions of mineral nutrition. Because the roots of fruit trees need extremely good aeration, the culture solution was sprayed on the roots, suspended in mid-air. Mechanical improvement is necessary, but the 256 rooted shoots grew as well as similar ones in the field; and clear deficiencies of potassium, iron and possibly manganese were established within the first season's growth.

A cheap precipitation method for rendering tap water sufficiently free of traces of heavy metals for use in the above experiment was tested toward the end of the season.

An interesting straight line relationship was found between the amounts of chlorophyll and carotene in normal and chlorotic apple leaves, whether the chlorosis was due to potassium or iron deficiency or to infection with acute mosaic virus.

Manganese deficient potato leaves contained less dry weight per unit wet weight and tended to curl more on drying than normal leaves. These facts suggest that this deficiency results in weak skeletal structure—a suggestion in harmony with the observation that manganese deficient wheat tends to ' lodge ' badly in the field.

A flame spectrographic method has been evolved for the quantitative analysis for potassium, manganese, magnesium, iron and copper in 50 mg., or even less, of dry leaf. Interference by silicon and phosphorus make it less satisfactory for magnesium. Some 1,700 microchemical analyses have been done, in collaboration with the Pomology Section. Improvements in the chemical and physical laboratories, carried out during the year, have allowed of greater output and have reduced congestion. The new laboratory for work on the organic constituents of fruit plants was occupied early in 1951 and has greatly increased the efficiency of this part of the Section.

Analytical methods.

The grinding of leaf and other samples to an impalpable powder has consumed much time in the past. A solution to most of the Section's problems of this kind seems to have been found in various forms of roller mill.

A little progress has been made on the fractionation of nutrient elements and there is hope that this will be developed more rapidly now that a quantitative flame method of spectrography is available.

Chemical.

A greatly improved Titan Yellow method for magnesium has been evolved. The new method for calcium, noted in the last report, has given good results after steps were taken to prevent interference by phosphates. The methods in use for iron, manganese and phosphorus have given satisfactory results, but there is a real need for a less tedious method for iron and for a more sensitive precise method for manganese. The sensitive blue ' tetrabase ' reaction for the latter element has been investigated and has so far yielded results as good as the permanganate method. Work on new methods for estimating nitrate and amino acids in plant material has yielded interesting results.

Spectrographic methods.

Flame method.—As stated above, this has now been put on a quantitative basis (see page 122).

Arc method.—No work was possible on this method until the end of the year.

Mass Spectrometer method.

Some progress has been made. In November, 1950, major alterations in design of the instrument were found necessary for our work.

Organic constituents of fruit plants.

In order to make use of the plants grown in spray culture, the methods described in previous reports have been adapted to be applicable to a single leaf ; a start has been made on developing quantitative methods of analysis for certain fractions.

The interesting relationship found to exist between the relative amounts of chlorophyll and carotene is referred to earlier. Co-operation with the Staff of the Research Institute of Plant Physiology has become even closer ; their potato material of various known levels of manganese nutrition has been invaluable as ' pilot material ' for work on the apple. This can be produced at a week or two's notice in winter, whereas similar apple material is produced at much greater expense in a year or more.

Work on the separation and identification of unknown constituents of particular interest is progressing, but much work remains to be done.

No qualitative difference in composition was found between healthy apple leaves and those infected with acute mosaic virus. Chlorotic leaves are deficient in both chlorophyll and carotene, as already mentioned.

Studies in nutrition.

Analytical determination.

Numerous analyses have been carried out during the year for a variety of studies.

Cover cropping.—In collaboration with the Pomology Section, analyses on 84 samples taken during 1949 and 1950 from apple trees subjected to different cover crop treatments on Plot L8a have been completed for the elements N, P, K, Ca, Mg, Fe, and Mn. Interesting differences have been found between the results for the two seasons and between trees growing in association with a cover crop and those on the clean cultivated plots.

Restoration of soil uniformity.—(See also page 27 ; also page 23 of the previous Annual Report). Eighty samples of mangold leaves, which showed clear differences in leaf colour, corresponding with the old tree positions, were analysed for the above seven elements, some 560 analyses in all. The only significant effect was that nitrogen in the leaves of mangolds grown in the tree position was lower than in surrounding positions, notwithstanding the fact that artificial fertilizers (sulphate of ammonia, sulphate of potash and super-phosphate) had been applied.

Seasonal changes in leaf composition.—Apple rootstocks M.I, M.II, M.IV, M.VII, M.IX and M.XVI were sampled from stoolbeds at approximately 18-day intervals between 18th August and 17th November, and 245 samples of the leaves analysed for the seven elements referred to above. The pattern was very similar for all the rootstocks, but varied in an interesting way for the different elements ; N, P, and K fell fairly regularly from beginning to end of sampling ; Ca, Mg and Mn rose steadily till senescence and then fell sharply, while the iron content of the leaves showed no regular change.

Visual leaf symptoms.—A start has been made on the analysis of leaf samples taken from trees, showing the typical visual leaf symptoms recorded by the Pomology Section, so that their records may be expressed, as far as possible, in terms of nutrient status.

The total number of routine analyses carried out during the year was 1,695.

Plant injection.

A few trees have been injected with a mixture of potassium phosphate and urea to see how far individual experimental trees of poor performance can be brought into sufficiently rapid growth for the experimental purposes in view (see also page 26).

Spray culture of apple rooted shoots.

Following on work at Long Ashton and at East Malling, an attempt has been made to grow rooted shoots by suspending them in mid-air and spraying their roots with culture solution. The solution was run on to a horizontal disc, rotated by a small electric motor. The disc was just below the centre of the lid of a container 3 feet in diameter. It flung the solution as a fine spray on to the bases of 16 pairs of rooted shoots, that were suspended through as many holes in the top of the container, near its circumference. The greatest difficulties arose in connection with ensuring a steady flow of culture solution on to the disc ; although these were not entirely overcome there is good hope of doing so by next season. Sixteen such containers were set up and eight of these were kept running during the growing season. In these, four treatments, using iron, manganese and potassium deficient nutrient solutions respectively, were applied ; in spite of a certain amount of temporary wilting through interruptions to the liquid supply, the 256 rooted shoots grew as well as similar ones planted in the field in the usual way. Shoots, planted in soil near the containers and watered frequently, grew rather better (producing an average of 34 leaves per plant instead of 24 in spray culture). The work, therefore, succeeded in its main purpose of evolving a spray culture method for the 1952 season.

It also established the fact that the effects of deficiencies of iron, potassium and possibly manganese could be produced by this method within one growing season. Typical symptoms of iron deficiency were apparent in six weeks and those of potassium deficiency were seen in 12 weeks ; the latter were typical, except that more of the dead leaf margins turned downwards than upwards. Late in the season the basal leaves on the manganese deficient plants showed autumn tints and fell off and one or two apical leaves on a number of shoots showed the chlorosis pattern typical of mild manganese deficiency.

Growth measurements, including leaf areas, shoot extension and fresh weights, were taken periodically ; and samples were taken for chemical analysis. One result already obtained has been mentioned, viz.: the interesting constancy of relation between chlorophyll and carotene.

The whole Section contributed to the success of this project and every member shared in the considerable amount of week-end work.

Studies in manganese deficiency.*

Studies of the physiological effects of manganese on carbon assimilation, respiration and nitrogen metabolism in the potato were continued.

Both isolated rooted potato leaves and rooted potato shoots of high and low manganese content were used as experimental material.

A highly significant positive effect of manganese on carbon assimilation rate per unit leaf area has been found. No significant difference in chlorophyll content of the two series was detected. It was concluded that manganese, apart from its relationship to chlorophyll production, has a direct effect in increasing the efficiency of carbon dioxide fixation.

Respiration studies, in agreement with last year's results, showed that high manganese rooted leaves and shoots have a significantly higher respiration rate than those having a low manganese content, but the addition of manganese to rooted leaves and plants which had been grown at a low manganese level did not increase the respiration rate even at the end of six days.

In preliminary experiments on nitrogen metabolism it was confirmed that nitrates accumulated in the leaves of manganese deficient plants.

Publications During the Year.

Goldschmidt, V. H. and Delap, A. V. **The spindle bush method of growing apple and pear trees. (Adapted from German.)** Fruit Year Book, 1950, 54-66 (K87).

Mason, A. C. **A new and rapid method for estimating small quantities of calcium in plant material. A preliminary note.** Rep. E. Malling Res. Sta. for 1950 (1951), 122-3 (K88).

——— **The estimation of iron in plant material.** Rep. E. Malling Res. Sta. for 1950 (1951), 124-6 (K89).

——— **An improved technique for precipitation of potassium with sodium cobaltinitrite.** Analyst, 1951, **76,** 176-7 (K90).

——— **A photo-electric micro Nephelometer.** Analyst, 1951, **76,** 172-6 (K91).

* This work is being carried out by members of the Staff of the Research Institute of Plant Physiology, Imperial College of Science and Technology, working in collaboration with the Biochemistry Section.

V. PLANT PATHOLOGY

By R. V. HARRIS

Bacteriosis of stone fruits.

The study of possible saprophytic stages in the seasonal cycle of the pathogen, *Pseudomonas morsprunorum* Wormald, was aided by the development of a selective medium for isolating it from sparse populations. Using this medium, experiments on the over-wintering of the pathogen on tree surfaces were repeated, but no evidence of survival this year was found.

The importance of the leaf scar as an avenue of infection in cherries (C284) was confirmed by further inoculations in the autumn. The inoculation of a range of cherry varieties by this method indicated a threshold concentration of inoculum for each variety, below which infections were rarely established. No clear evidence was found that this concentration varied with the natural resistance of the variety.

Indications were obtained from pilot spraying experiments (Annual Report for 1949, page 40), recently completed, that the timing of the autumn spray could profitably be adjusted, and this will be fully tested in a new experiment. Meantime, application in mid-October is recommended, and the best results were obtained from spraying in both autumn and spring (see also under ' Internal-therapy ' below).

Cauliflower disease and related disorders of strawberry.

In addition to ' Cauliflower ' disease of strawberry, the bacterium *Corynebacterium fascians* was found associated with ' Red Plant ' and with certain other, as yet undescribed, field symptoms of this host. The results of work with the Entomology Section confirming the etiological association of this bacterium with the eelworms *Aphelenchoides ritzema-bosi* and *A. fragariae* are being prepared for early publication.

Apple and Pear Scab.

A collection of 50 morphologically different isolates of *Venturia inaequalis*, the apple scab fungus, and of 34 of *V. pyrina*, the pear fungus, were maintained in culture by the mineral oil conservation method. A comparison of the sporulation potential of these isolates showed marked differences within the former, but attempts at a similar examination of the *V. pyrina* isolates were complicated by the difficulty of obtaining spore suspensions of this fungus free from mycelial fragments. A study of this led to the elucidation of further differentiating mycelial characters.

A start was made on the determination of the relative pathogenicities of six of the isolates of each fungus. Test inoculations were made at intervals throughout the season on trees of selected scion and stock varieties of apple and pear, grown in pots. Batches of the trees were transferred at intervals to a glasshouse for foliage inoculation with conidial suspensions in water, using a ' sleeving ' which yielded very satisfactory results. Wide differences in susceptibility, under the conditions of the experiment, were related to variety, stock, and fungal isolate.

Verticillium Wilts.

An account of research on Verticillium Wilt of strawberry from 1944 to 1948 was published (C282). The incidence of this disease was shown to bear no detectable relation to that in the plantation from which the planting stock was derived, but was primarily related to the inoculum content of the soil on which the runners were grown. The common British varieties tested showed no marked differences in susceptibility.

In the absence of the senior worker in North America research on the hop diseases was limited to the continuation of the trials of new varieties for resistance, and to the laboratory studies of the physiology and toxin relations of the progressive and fluctuating strains of *V. albo-atrum*.

Primary resistance trials of 36 new hop seedlings were made, 13 of which were bred at Wye College. Some of these showed high resistance and will be propagated for further trial. Records were continued on the four large-scale commercial plantings of the more promising of the older seedlings, and in this connection it is interesting to note that OR55 (Keyworth's Midseason) variety continued to show, in 1950 and 1951, a progressive diminution, with increasing age, in the proportion of hills developing wilt symptoms.

The investigation aiming at the differentiation in pure culture of the physiologic races,

morphologically identical, causing the ' progressive ' and ' fluctuating ' types of outbreak failed to yield any clearly defined differentia. A fairly consistent feature, however, was the fact that on suitable media the races differed with some consistency in the frequency of mutational sectoring. No direct qualitative relation between strain pathogenicity and the production of toxic substances in artificial culture was found, though this does not exclude the possibility that under natural conditions of infection such differentia might exist.

Progress in the purification of the toxic compounds in *Verticillium* culture fluids was slow owing to the continued difficulty of assaying toxin activity. The inverse relation between water uptake by young tomato plants and toxin activity was used, but the extreme plant to plant variability which occurred required large plant units and impracticably large quantities of test solutions. Single-leaf-assay is now again being investigated on the assumption that measurable physiologic disturbances may occur before the symptoms of wilt appear. An account of the methods devised for examining this assumption appears elsewhere (see p. 149).

Virus diseases of tree fruits.

Further interesting developments in the study of Apple Mosaic are the subject of a progress report elsewhere. An extensive and systematic examination of the more important Malling apple rootstocks for Rubbery Wood virus was started (see page 131).

Indexing experiments with cherry viruses started in 1950 showed, during the present year, that although peach, apricot, mazzard, morello, and mahaleb species are good indicators of the Necrotic Ring Spot, or Tatter Leaf, group of viruses (Annual Report, 1950, page 209), none is better than the F12/1 mazzard for the other virus groups. There are, however, some masked viruses in cherries which cause symptoms on peach.

Three pear viruses were distinguished by the use of quince seedlings as indicator plants, and a start was made on the study of the virus diseases of plum, a field which seems likely to be even more complex than that of cherry virus diseases.

Progress was made in the development of a suitable technique for indexing stone-fruit viruses. Using very young seedlings in the new virus-research glasshouse, it was found possible to obtain symptoms within one month of inoculation. The perfecting of some such technique is an essential preliminary to an intensive study of these viruses, and to a search for the vectors.

Work on the direct inactivation of tree and soft fruit viruses is reported below.

Virus diseases of soft fruits.

A note on the identification of insect vectors of strawberry viruses additional to the strawberry aphis (*Pentatrichopus fragaefolii*) has been prepared for publication. The economic importance of these insects in this role remains to be determined. Early tests for potential alternative host genera also gave positive results in one species of *Potentilla*. The main emphasis in the strawberry programme, however, was on the spread and control of the viruses in the plantation, and on field trials, with the Entomology Section, to investigate the relative importance of winged and wingless aphids in the spread of the different viruses and the control afforded by the use of a systemic insecticide. A study of the rate of virus spread within the variety Auchincruive Climax has shown that virus-free stock, planted in 1947, had become entirely infected with mild-crinkle virus by the spring of 1951.

A report on newly identified virus diseases of bush fruits has been prepared (see page 133).

Virus diseases of the hop.

Work on these diseases was retarded during the year by staff changes ; positive results, however, were recorded in the development of experiments started last year to determine insect vectors of Mosaic disease. During the year a description of the widely distributed Split Leaf Blotch disease was published. On conclusive evidence of graft transmitability this disease is presumed to be of virus origin. The periodic exposure of mosaic-free but susceptible (indicator) hop plants in a hop-garden of mosaic carriers provided some evidence of natural transmission of the disease in May and June. All attempts to transmit the Nettlehead virus in the soil have so far failed, but it has begun to spread in an experiment where diseased and healthy plants have been kept in proximity, in sunken pots, for three seasons.

Investigations on fungicides in the field.

A report on the results of the testing of new fungicides on plantation trees, in collaboration with the Plant Protective Chemistry Section, has been prepared (see page 200).

The method, previously reported, for the primary *in vivo* testing of protective fungicides using hedges of susceptible apple stocks, was successfully applied during the year in determining the relation between dosage and concentration in low-volume spraying with atomized concentrated lime-sulphur. Records in this experiment of the effectiveness of the variant treatments against Apple Scab and Apple Mildew were encouraging.

The same method was also used for tests of new organic fungicides applied as dilute sprays against Apple Mildew, and further tests were made to determine the merits of autumnal protectant spraying against Apple Canker. The information from the latter tests will be incorporated in a modification of the large scale field trial started in 1950 on a commercial plantation of Cox's Orange Pippin in West Sussex in collaboration with the N.A.A.S. This trial is being simplified to investigate the efficacy of spraying in a plantation where severe canker-infection already exists.

Internal-therapy.

Following the confirmation, noted above, of the important part played by leaf-scar infection in cherry bacteriosis, experiments on the liquid injection of cherry trees with 8-hydroxy quinoline potassium sulphate and other substances, found to be active against the bacterium in liquid culture, were started in the autumn with the object of rendering the tree-sap toxic to it at this point of entry.

Attempts to obtain virus-free plants of strawberry, apple, and cherry, by subjecting infected plants to high temperatures for periods up to the death point for each variety yielded results which, though negative, were sufficiently encouraging to warrant continuation. An investigation of the use of chemical inactivants against fruit viruses was also started.

Publications During the Year.

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Cadman, C. H. and Wood, C. A. **Raspberries in Scotland.** Sci. Hort., 1950-51, **10,** 124-33 ; Rep. E. Malling Res. Sta. for 1950 (1951), 203-8 (C268).

Posnette, A. F. **Virus diseases of sweet cherries.** Rep. E. Malling Res. Sta. for 1950 (1951), 209-10 (C269).

Cadman, C. H. and Harris, R. V. **Raspberry virus diseases : a survey of recent work.** Rep. E. Malling Res. Sta. for 1950 (1951), 127-30 (C270).

Moore, M. H. **Brown Rot of apples : note on infection associated with hail bruises and lenticles.** Rep. E. Malling Res. Sta. for 1950 (1951), 131 (C271).

Preston, A. P., Moore, M. H. and Bennett, M. **The influence of rootstock on spray damage in apple.** Rep. E. Malling Res. Sta. for 1950 (1951), 132-6 (C272).

Crosse, J. E. and Bennett, M. **Black Rot and Leaf Spot of apple due to *Physalospora obtusa* (Schw.) Cooke.** Rep. E. Malling Res. Sta. for 1950 (1951), 137-8 (C273).

Paine, J. **The treatment of hop seed to improve germination.** Rep. E. Malling Res. Sta. for 1950 (1951), 139-40 (C274).

Wood, C. A. **Variety trials, raspberries in Scotland.** Fruit-grower, 1950, 846-7 (C275).

Keyworth, W. G. **Split Leaf Blotch disease of the hop (*Humulus lupulus*).** J. hort. Sci., 1951, **26,** 163-8 (C276).

Harris, R. V. **Some scientific aspects of the certification schemes for fruit plants.** Ann. appl. Biol., 1951, **38,** 538-40 (C277).

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Prentice, I. W. and Woolcombe, T. M. **Resolution of strawberry virus complexes. IV. The latent period of virus 3 in the vector.** Ann. appl. Biol., 1951, **38,** 389-94 (C279).

Moore, M. H. **Apple Scab.** Fruit-grower, 1951, 892 (C280). Grower, 1951, **35,** 1005 (under different title) ; Gdnrs' Chron., 1951, **129,** 161-2 ; J. Kent F.U., 1951, **69,** 94.

Keyworth, W. G. and Bennett, M. **Verticillium Wilt of the Strawberry.** J. hort. Sci., 1951, **26,** 304-16 (C282).

Keyworth, W. G. **A Petri-dist moist chamber.** Trans. Brit. mycol. Soc., 1951, **34,** 291-2 (C283).

Crosse, J. E. **The leaf scar as an avenue of infection for the Cherry Bacterial Canker organism, *Pseudomonas mors-prunorum* Wormald.** Nature, 1951, **168,** 560 (C284).

VI. ENTOMOLOGY

By A. M. MASSEE

Tree fruits.

Routine counts of capped blossoms of the Apple Blossom Weevil (*Anthonomus pomorum* (L.) Curt.) have continued on selected plots to observe the rate of infestation following elimination of this pest in 1948.

Inoculations have been made for the second year running in the insectary and orchard house to test the resistance of certain apple rootstocks and of seedling varieties to attacks of the Woolly Aphid (*Eriosoma lanigera* Hausm.). All the seedlings which exhibited resistant qualities last season again proved resistant. Fifty-four selections of the M.IX Crosses were also tested ; all proved very susceptible ; in many cases the infestations were such that the stocks died. Eighty of the Malling-Merton series of rootstocks were tested again, and all proved highly resistant throughout the growing season. This is significant since some of these seedlings raised small colonies of aphids in 1949.

The low level of infestation allowed of little information being obtained on the effect of sprays containing DDT, BHC and parathion, applied at the green cluster stage, for the control of caterpillars of the Winter Moth and Tortrix groups.

Biological studies of the Apple Sawfly (*Hoplocampa testudinea* Klug) have been continued. Further spraying trials were carried out to determine the effect of parathion, nicotine and BHC when applied at various dates after petal fall.

The infestation of Pear Sawfly (*Hoplocampa brevis* Klug), a continental pest which was first noted in 1949, was again examined, and control measures recommended. It is considered that the original outbreak has been eliminated, but two further infestations have been noted in the vicinity. These are being investigated with a view to their elimination.

Investigations on the Fruit Tree Red Spider Mite (*Metatetranychus ulmi* Koch) have again been continued at the Field Laboratory, Great Braxted, Essex and at East Malling. In spite of the comparatively cool and wet summer and autumn, five complete generations of the mite were recorded, and very serious damage to apple orchards was widespread throughout Essex and Kent. One outstanding observation of the season was the comparatively short period in which the bulk of the winter eggs hatched in the spring. This allowed of very accurate ' timing ' of the first application of the summer acaricides on the experimental plots and on the farm. Indeed, very few summer eggs were present at the time of this application. The dispersal phase of the mite started late in July and continued during August and September, but did not occur on a sufficiently large scale at the experimental plots at Writtle to interfere with the results of the experiments in progress there.

During the season a large scale summer spraying trial was carried out on Laxton's Superb apple on the farm of the Essex Institute of Agriculture, Writtle. Seven potential acaricides were used, and of these sprays the early applications of parathion, parathion plus diphenyl sulphone and O-ethyl-O-P-nitrophenyl benzenethiophosphonate (EPN300) were outstanding in their performance, especially in reducing the mite populations. The possible ovicidal effect of these and other sprays was also examined ; diphenyl sulphone proved outstanding as a summer ovicide. Phytotoxicity tests on all the sprays used in the main trial were carried out on a plot of Cox's Orange Pippin situated at Writtle.

The investigation into the beneficial insect and mite populations of orchards has continued, together with biological studies of several species, in particular on the group of predatory mites. A detailed report is in the press. Records were taken of the beneficial insects in the summer spraying trial at Writtle, but results as to the effect of the various acaricides were inconclusive owing to the scarcity of predators throughout the orchard. This scarcity has been general throughout Essex orchards, but was not so noticeable in Kent, where such species as *Blepharidopterus angulatus* Fall. and *Stethorus punctillum* Weise were relatively numerous. Observations have been made on the effect of various routine spray programmes on orchard populations. In co-operation with the Plant Protective Chemistry Section a trial has been started at Ryarsh in Kent, with several fungicides, to examine the effect of fungicides not containing sulphur upon the frequency of Typhlodromid Mites in comparison to lime-sulphur.

Detailed biological studies of all species of aphids known to infest apple, red and black currant and gooseberry, are in progress. Preliminary observations are being made on other fruit aphids as material and time permits. A trial was carried out on apples, currants and gooseberries to compare the ovicidal properties of DNC-petroleum with DDT, BHC and parathion applied shortly after hatching of the winter eggs.

The detailed study of the Codling Moth (*Cydia pomonella* L.) has been continued. The overwintering of larvae in various situations and the emergence of moths, are being investigated, and to aid this work use is being made of bait traps and a mercury vapour light trap. Work has continued on the spraying of orchard boxes and packhouses with DDT ; and various new insecticides are being tested in the orchard and compared with lead arsenate in conjunction with the Plant Protective Chemistry Section.

Adoxophyes orana (F.R.) (=*Capua reticulana*), a species of Tortrix, has been recorded in Great Britain from North-East Kent. The biology of this species is being studied to ascertain the emergence of larvae from their overwintering haunts, their feeding habits, the flight periods, and the oviposition of the adults. There are two generations each year, and extensive damage has been caused by the larvae in some orchards.

The Bud Moth (*Spilonota ocellana* Schiff.) and two other species of Tortricids, *Cacoecia heparana* Schiff. and *Cacoecia podana* Scop., are also being studied in detail. The parasites and other natural enemies of all these species are being noted.

Field trials on modified control measures for the Red Bud Borer (*Thomasiniana oculiperda* Rueb.) are being continued.

Small fruits.

Studies are continuing on the biology of the Strawberry Eelworms (*Aphelenchoides ritzema-bosi* Schw. and *Aphelenchoides fragariae* Ritz. Bos.), including an investigation of survival in the soil. Collaborative work with the Plant Pathology Section has confirmed the etiological association between eelworms and *Corynebacterium fascians* and suggests that these organisms are present together in a much wider range of symptom types than hitherto believed.

Further investigations of this subject and of the possible association of the Meadow Nematode (*Pratylenchus pratensis* de Man) with the Strawberry Black Root Rot complex are in hand. Field and insectary experiments on the chemical control of strawberry eelworms and the Stem Eelworm (*Ditylenchus dipsaci*) are continuing.

Very light infestations of the Strawberry Aphid (*Pentatrichopus fragaefolii* Cock.) have so far militated against any decisive results in trials designed, in collaboration with the Plant Pathology Section, to compare the control afforded by different concentrations of Schradan, the relative efficiency of automatic and hand spraying, and the incidence of virus infection following various spray treatments.

A study of the fauna of the cultivated strawberry is being continued. Compilation of a list of insects, including those recorded by other workers, is nearing completion.

Investigations on the control of the Strawberry Tarsonemid Mite (*Tarsonemus pallidus* Banks) have continued in collaboration with the Imperial College of Science, London.

A field trial comparing parathion and DDT for the control of the Black Currant Leaf Midge (*Dasyneura tetensi* Rueb.) will be repeated. Two papers dealing with the bionomics and control of the Midge are ready for publication.

Systematic study of the Gall Mites and Red Spider Mites.

Several species have been received for determination, and the species contained in the family *Parasitidae*, which are closely associated with the Fruit Tree Red Spider Mite, are being studied.

Publications During the Year.

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Massee, A. M. **Notes on some interesting insects observed in 1950.** Rep. E. Malling Res. Sta. for 1950 (1951), 141-7 (D228).

Collyer, E. **A method for the estimation of insect populations on fruit trees.** Rep. E. Malling Res. Sta. for 1950 (1951), 148-51 (D229).

Blair, C. A. **Damage to apple leaves by the Fruit Tree Red Spider Mite, *Metatetranychus ulmi* (Koch).** Rep. E. Malling Res. Sta. for 1950 (1951), 152-4 (D230).

Marlé, G. **Observations on the dispersal of the Fruit Tree Red Spider Mite, *Metatetranychus ulmi* (Koch).** Rep. E. Malling Res. Sta. for 1950 (1951), 155-9 (D231).

Groves, J. R. **A synopsis of the world literature on the Fruit Tree Red Spider Mite, *Metatetranychus ulmi* (C. L. Koch, 1935) and its predators. (With a brief review of the problem by A. M. Massee.)** Commonwealth Inst. of Entomology, 1951 (D232).

PITCHER, R. S. **Raspberry Cane Midge and Midge Blight.** Fruit-grower, 1951, No. 2886, 712-3 ; Grower, 1951, **35,** 766-7 (D233).

DICKER, G. H. L. *Agonum dorsale* **Pont. (Col., Carabidae) : an unusual egg-laying habit and some biological notes.** Ent. mon. Mag., 1951, **87,** 33-4 (D234).

GROVES, J. R. **New caterpillar attacks apples in England.** Grower, 1951, **36,** 458 (D240).

MASSEE, A. M. **A spray programme for 1951.** Kent Fmrs' J., 1950, **68,** 190-1 (D241).

——— **The Fruit Tree Red Spider Mite and its control.** Fruit Year Book, 1950, 81-3 (D242).

GROVES, J. R. *Adoxophyes orana* **F. R. (Lep., Tortricidae), a moth new to Britain.** Ent. mon. Mag., 1951, **87,** 259 (D243).

MASSEE, A. M. **The Codling Moth and its control.** Fruit Year Book, 1951-2, 74-6 (D244).

VII. PLANT PROTECTIVE CHEMISTRY

By A. H. M. KIRBY

Laboratory investigations.

The laboratory investigations carried out during the year covered a wide field and included studies on formulation, spray damage and spray residues in addition to those on ovicides, insecticides and fungicides.

Ovicides.

The exploratory study of compounds related to benzyl alcohol in relation to penetrant action has been extended to many further chemicals, using winter eggs of the Fruit Tree Red Spider Mite and azoxybenzene as the toxicant. The possible penetrant action of benzyl alcohol with a range of insecticides, ovicides and acaricides was also tested on this egg.

Eggs of *Aphis pomi* Deg. were used to examine the role of the surface active agent in formulations of nicotine, shown by Shaw and Steer to be ovicidal towards this egg in the presence of sodium oleate, but not of sulphite lye-petroleum. Eggs of this pest were also used to compare the results of dipping with those of spraying, using DNC-oil emulsions.

A note on aiding penetration of ovicides was published (Q64) and also a full account of the work carried out in 1949 and 1950 (Q63). The Tomato Moth, *Diataraxia oleracea*, has been raised on cabbage seedlings under controlled conditions as a source of a convenient egg for aided-penetration studies ; preliminary experiments with the eggs have been carried out.

Insecticides.

Although the order of activities by a dipping technique against adult females and summer eggs of the Fruit Tree Red Spider Mite for Santobane A and two analogues is N,N-amyl benzyl *cyclo*hexylamine > N,N-amyl benzoyl *cyclo*hexylamine > N-amyl *cyclo*hexylamine, the order (by injection in olive oil) against *Locusta migratoria migratorioides* is N-amyl *cyclo*hexylamine > N,N-amyl benzyl *cyclo*hexylamine > N,N-amyl benzoyl *cyclo*hexylamine.

Attempts are being made to follow the course of toxicants injected in oils into locusts by the addition of fat-soluble dyes to the oils. Indications are that vegetable oils are dispersed throughout the haemocoele rather than concentrated in the fat-body.

Fungicides.

A considerable proportion of the year has been devoted to improving the glass-slide germination test. It is hoped to make this an efficient tool for fundamental studies of fungitoxic action. It has proved possible to use the Vicker's Projection Microscope for counting spores and this has considerably reduced fatigue at this exacting stage of the procedure. The search for a satisfactory spreading agent is being vigorously pursued, and also for a technique of making grooves with good edges in ordinary microscope slides. These and other difficulties will have to be overcome before the method can be regarded as fully adequate.

An antibiotic, antimycin A, at 1μg/ml. (0·0001 per cent) gave 35 per cent inhibition of germination of *Venturia inaequalis*, strain E1.

The results of studies on the activity of various organophosphorus compounds towards *V. inaequalis* and *V. pirina* have been published (Q62).

Spray damage.

Collaborative studies with the Plant Physiology Section and the Research Institute of Plant Physiology have centred on the problems of assessing damage objectively, and of studying the role of wetting agents in the arrival, retention and phytotoxicity of spray materials. The raspberry leaf has an under-surface notoriously difficult to wet, and this has been used in most studies. Criteria for assessing the performance of wetting agents have been established for this leaf. A method of assessing damage by water loss has been worked out and is likely to apply to any spray material causing death of cells, e.g. copper, but not to materials causing sub-lethal damage. Chlorophyll estimation has also been employed, and may be of value in the latter case. Papers on this work appear on pages 115 and 119 ; a further paper is in preparation.

Organic chemistry.

Series of compounds synthesized for biological testing included chlorinated phenylbenzenesulphonates, N-substituted anilines and *cyclo*hexylamines, phthalic and chlorphthalic esters and 1-substituted 3:5-dimethyl-4-nitrosopyrazoles. A commercial organophosphorus ester, E838, was purified by absorption chromatography.

Formulation.

Most of the materials tested for biological activity in laboratory or field were formulated here, and special studies were made in certain cases, especially for field trials, to find suitable formulations.

Chemical analysis.

Analyses were made of certain commercial products used in various field trials ; it was found possible to estimate 4:6-dinitro-2-*sec*-butylphenol (DNBP) by the method prescribed for phenols in DNC-petroleum oil winter washes.

Considerable work was done on the release of soluble arsenic from metallic arsenates by dilute lime-sulphur solutions. Indications were obtained that zinc fluoroarsenate is not the only arsenate which releases much less soluble arsenic than does lead arsenate, but occlusion of water-soluble arsenates, e.g. sodium arsenate, in commercial products may occur.

Work has begun on the problem of residues on fruit from mercurial sprays applied in June and July. It is unlikely that a fungicide such as phenyl mercury chloride, applied in the recommended way for scab control, would lead to any significant residue, as the mercury level, 0·003 per cent, is so low to begin with. Later applications in the form of mercurated lead arsenate, especially if more than one application is made, might yield measurable quantities of mercury (as well as lead and arsenic) on the fruit, at least on the earlier varieties. Mercury, however, is a notoriously difficult element to estimate, especially in the presence of much organic matter, and further work on the method will be undertaken before the next season.

Field investigations.

Collaboration with the Entomology and Plant Pathology Sections has continued for the field evaluation of insecticides, acaricides, ovicides and fungicides, and the effect of such materials on beneficial fauna of the orchard. Phytotoxicity trials also continued, some being carried out on the new plot which is being developed for this type of work.

Insecticide trials.

Apple Sawfly.—Further investigations into the control of Apple Sawfly had to be postponed as this pest was present at too low a level. A summary of the present position has been published (Q58) and a paper was read before the Association of Applied Biologists (Q65).

Codling Moth.—A trial was made in collaboration with the Entomology Section to compare toxaphene, aldrin, dieldrin and dinitrocaprylphenyl crotonate with DDT and with lead arsenate for control of this pest. DDT was outstanding, but it is not yet possible to assess the relative activities of the other materials.

Fruit Tree Red Spider Mite.—Laboratory tests in the winter fell into three groups : (*a*) tests of a few substances for ovicidal activity ; (*b*) tests of a considerable range of chemicals for penetrant action, using a standard toxicant ; (*c*) tests of a few toxicants in the presence of a standard penetrant.

Summer ovicide tests were made with a series of chlorinated phenyl benzenesulphonates, esters of phthalic and chlorphthalic acids, N-substituted anilines and *cyclo*hexylamines, some organophosphorus compounds related to parathion, and a small miscellaneous group. Acaricide tests were confined to isomers of *n*-octyl phthalate and chlorphthalate, organophosphorus compounds, dieldrin, aldrin and antimycin A. Results were rather erratic and relative activities hard to assess, and it is hoped to improve the test methods before further assays are attempted.

In the field, a winter trial on Worcester Pearmain was carried out with a commercial sample of 4,6-dinitro-2-*sec*-butylphenol formulated as the triethanolamine salt. At 3 quarts per 100 gallons control of winter eggs was equal to that given by a standard DNC-petroleum spray ; but poor control was achieved at 2 quarts, even when good wetting agents were added. On the other hand, promise was shown by a spray containing 2 quarts plus a polyethylene polysulphide sticker.

Summer trials indicated that EPN300 is at least as good as parathion at the same strength, but that E838 is inferior ; another acaricide, dinitrocaprylphenyl crotonate, was also comparatively ineffective. The ovicides diphenyl sulphone, 4-chlorphenyl benzenesulphonate and 2,4-dichlorphenyl benzenesulphonate were very promising, the first being used in conjunction with a low concentration of parathion with outstanding success.

The predator aspect.

A preliminary experiment in collaboration with the Entomology Section in 1950 indicated that the glyoxalidine fungicides, 341C and 341SC, were harmless to predators of the Fruit Tree Red Spider Mite, which are normally present in Essex orchards. In 1951, permission was obtained to use part of a commercial orchard in Kent to extend this investigation. 341SC, and another promising fungicide TP13, were compared with lime-sulphur and with dispersible sulphur in two pre- and two post-blossom sprays. Counts were made of a predatory mite which is killed by sulphur. Preliminary examination was also made of three other new fungicides (ziram, thiram and zineb) and of two new insecticides (toxaphene and aldrin).

Fungicide trials.

A number of trials were carried out during the year in collaboration with the Pathology Section. A review of work with organic fungicides during the past 15 years has been prepared (page 200).

Pear Scab.—Two glyoxalidine formulations, a 50 per cent wettable powder based on SR406, and another based on ziram were applied twice pre-blossom and once post-blossom on three varieties, including Doyenné du Comice. The incidence of Pear Scab was too low to allow of the effect of the sprays being assessed, but no damage was seen on any variety.

Apple Scab.—Trials with fungicides were carried out on dwarf pyramids and on mature trees at the Station, and in two orchards outside, one with help from the N.A.A.S. Main interest has centred round the alkyl glyoxalidines, a formulation of which is likely to be available to growers in this country in 1952, and TP13, a 50 per cent wettable powder based on N-trichlormethylthiotetrahydrophthalimide (N-trichlormethyl-S-tetrahydrophthalylsulphenamide, SR406) which is a very promising material. The latter, on Cox's Orange Pippin on M.IX, gave especially good control when used post-blossom following lime-sulphur pre-blossom ; 341SC and thiram were much less effective.

Compared on leaves of Newton Wonder and Bramley's Seedling, of two nitrosopyrazoles, at 0·05 per cent, J49 again gave good results and was superior to J55 which only differs by the absence of the chlorine atom. Zinc ethylene bisdithiocarbamate (zineb) at 0·2 per cent and dinitrocaprylphenyl crotonate at 0·05 per cent were equal to lime-sulphur at 1 per cent, but ziram, even at 0·2 per cent, was markedly inferior in contrast to experience in 1949 and 1950. Considerable promise was shown by manganese dimethyl dithiocarbamate (manam) at 0·2 per cent.

Apple Mildew.—A trial has been set up to assess the control of this disease afforded by several alternatives to lime-sulphur for Scab control.

Spray damage.

A number of new materials and mixtures of materials were tested by single branch treatments on Cox's Orange Pippin on M.XII. A review of this work and that carried out on the same plot in 1949 and 1950 has been prepared (see page 183).

Following observation of damage on pears sprayed with mercurated lead arsenate, an investigation was carried out on Conference on Quince A on the new spray-damage plot (see page 187).

No damage was observed on Victoria plums sprayed with toxaphene at 1 lb. per 100 gallons (see page 184).

Publications During the Year.

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——— **An important new type of wetter.** Rep. E. Malling Res. Sta. for 1950 (1951), 214 (Q59).

——— **Trials of zinc fluoroarsenate against Codling Moth,** *Cydia pomonella* **L.** Rep. E. Malling Res. Sta. for 1950 (1951), 160-3 (Q60).

——— and McKinlay, K. S. **Laboratory experiments on the toxicity of potential acaricides.** Rep. E. Malling Res. Sta. for 1950 (1951), 164-71 (Q61).

——— and Frick, E. L. **The fungistatic activity of certain organophosphorus insecticides.** Rep. E. Malling Res. Sta. for 1950 (1951), 172-6 (Q62).

McKinlay, K. S., Kirby, A. H. M. and Allen, M. **Experiments on increasing the penetration of ovicides and insecticides.** Rep. E. Malling Res. Sta. for 1950 (1951), 177-86 (Q63).

McKinlay, K. S. and Kirby, A. H. M. **Benzyl Alcohol as an aid to penetration of certain ovicides.** Nature, 1951, **167,** 153 (Q64).

VIII. SCIENTIFIC LIAISON SECTION

By H. B. S. MONTGOMERY

Advisory correspondence showed a slight decrease over previous years, falling to 1,470. Of these some 200 were passed to the advisory services, some direct and others after further elucidation. Correspondence relating to visits, exhibits, lectures and similar subjects amounted to a further 980 letters.

Visitors, omitting Members' Days and special courses, were more numerous than in the previous year with 66 parties, amounting to 1,950 persons, and 695 individual visitors. Of the 325 that came from overseas, 67 were specialists and many of these made visits lasting more than one day. Programmes for these overseas visitors receive special attention as these contacts are very valuable to the Station, particularly as overseas travel, even to Europe, is now so difficult.

Interesting problems in planning were raised by the visit of the Royal Society when a very wide and detailed field of work had to be presented in the course of a few hours. Similar problems arose also with the visits of the Association of Applied Biologists, the Royal Meteorological Society, the Parliamentary and Scientific Committee, the Royal Horticultural Society's Fruit Group and the Horticultural Education Association.

Three Members' Days were organized, on research on plant analysis and nutrition, rootstock scion incompatibility, and plums and gages. The attendances on these occasions was as high as was convenient, totalling 410 in all. Rehearsals, to which advisory officers of the N.A.A.S. and Local Education Authorities were invited, preceded each of these days. A special day was also arranged for the Governing Members, to bring new lines of work to their notice, and was attended by 28 of them. The Local Day was organized on a Wednesday this year, to provide an opportunity for local people having a mid-week half-day to see something of the work in the field and laboratories. This event was not so widely advertised as last year, but the attendance of 140 fully justified holding the day. Assistance was given to the Red Spider team of entomologists in Essex in holding a visiting day at Writtle for those specially concerned with the investigations.

Seven popular articles were published during the year and help given to members of other Sections in writing similar articles. The editing of Part IV of the Annual Report continued the responsibility of the Section and in addition general help was given in editing the Report and in proof reading. Much time has been spent in assisting the N.A.A.S. in the production and revision of the official fruit bulletins and advisory leaflets.

Nine lectures on the work of the Research Station and its application to commercial and amateur fruitgrowing have been given in Birmingham, Northwich, Rayleigh (Essex), King's Lynn and Hailsham as well as in places in Kent. Members of the section judged fruit at the Marden and the East Kent Fruit Shows, and at the Platt, Cobdown and Rainham Horticultural Shows. Six exhibits were staged, including one on apple breeding for the Linnean Society, and one on the prevention of frost damage by water sprinkling at the Chelsea Flower Show.

In connection with the South Bank Exhibition of the Festival of Britain, the Station shared responsibility with the Long Ashton Research Station and the John Innes Horticultural Institution for maintaining an exhibit of fruiting plants in the Country Pavilion. As East Malling was nearest to the site, it had the largest share in the exhibit, and in spite of a number of unforeseen difficulties the allotted space in the gallery was successfully filled for the whole period of the festival. The Station's contributions were strawberries in May with emphasis on freedom from virus diseases, raspberries in June showing the new Malling varieties, and apples from the latter part of July till the end of September. The fruiting apple trees illustrated some rootstock effects and the choice of rootstocks for trained trees ; they were supplemented by a series designed to show how an apple tree is raised. Towards the end of the period, space was found to illustrate the method of raising virus-free strawberry runners.

Collaboration with the N.A.A.S. was maintained by frequent personal contacts, especially with the Provincial Advisory Officer –Fruit, by correspondence, by service on committees and by regular contributions to the N.A.A.S. Quarterly Review. The usual courses have been held for officers concerned with the certification of rootstocks and hops. The annual two-day visit of a third of the horticultural officers was also held. In all, visits by N.A.A.S. and L.E.A. officers totalled 238. The rapid development of the N.A.A.S., and the steadily growing experience of its younger officers, is enormously increasing the responsibilities of the Section in its dual task of assisting the Service and of reducing to the minimum possible the inevitable calls upon the time of the research worker.

The various information services for the research staff were kept up and the series of lectures for plantation assistants organized.

Members of the Section joined in suitable lines of research as time permitted, especially the studies on peach culture (page 28) and on root excavations.

Publications During the Year.

Montgomery, H. B. S. **Fruitgrowing and research.** The British Farmer, 1950, No. 29, 8 (T31).

——— **Windbreaks.** N.A.A.S. Quart. Rev., 1950, No. 10, 77-9 (T32).

——— **Water sprinkling against frost damage.** N.A.A.S. Quart. Rev., 1951, No. 11, 121-3 (T33).

Coker, E. G. **A progress report on experiments with rabbit repellents.** Rep. E. Malling Res. Sta. for 1950 (1951), 87-9 (T34).

Montgomery, H. B. S. **Maleic hydrazide—a new growth inhibitor.** N.A.A.S. Quart. Rev., 1951, No. 12, 165-6 (T35).

——— **East Malling Research Station.** Leaflet prepared for Festival of Britain, 1951 (T36).

——— **Fruit culture in Kansas.** N.A.A.S. Quart. Rev., 1951, No. 13, 27-9 (T37).

Painter, A. C. **Gooseberries in the garden.** Fruit Year Book, 1951-2, 77-84 (T40).

A. R. C. SCOTTISH RASPBERRY INVESTIGATION

By R. V. HARRIS and C. H. CADMAN

On 1st April, 1951, the staff and activities of this Investigation were transferred, with the approval of the Agricultural Research Council, to the newly constituted Scottish Horticultural Research Institute of the Department of Agriculture for Scotland, and came under the direction of Dr. T. Swarbrick. The eighth and last annual report which follows therefore covers the period up to 31st March of the present year.

Virus diseases.

A report on the position reached in the investigation of these diseases has been published (C270). The results of grafting experiments, begun in 1950, confirmed that the mild, medium, and severe Vein Chlorosis diseases are caused by related viruses, and that mild and severe Yellows are also caused by related strains of one virus. At least three other distinct types of Yellows diseases have been identified. Evidence was also obtained that decline of Lloyd George is caused by a combination of severe Mosaic 2 and a second virus, provisionally named Bushy Dwarf (C270). This latter is now suspected to be identical with the Curly Dwarf virus of Prentice and Harris.

The field experiments at the Macaulay Institute for Soil Research, Aberdeen, and at West Park, Dundee, designed to provide information on the effect of virus infection on vigour and productivity of Lloyd George and other varieties, were discontinued. Work on these lines appears to be unrewarding until more accurate comparisons of the effect of individual viruses can be made. But studies on the rate and manner of spread in the field of certain mosaic viruses are being continued.

Stock testing work.

Selections of Malling Jewel and Malling Enterprise of low virus content were made on the basis of the results from graft tests to Norfolk Giant and St. Walfried. These samples are being used to build up re-selected stocks of these varieties.

Nuclear stock propagation scheme.

A third distribution of D1 (New Zealand) Lloyd George stock was made last autumn from a harvest of 26,000 canes from the nursery at Strathallan Castle, Auchterarder. A new plot of this variety has been planted at Muirdrum, Angus. Some 3,000 canes of a carefully rogued stock of Malling Jewel and 1,000 of a similar stock of Malling Enterprise were also distributed to propagators in the United Kingdom. Small quantities of the above and of Malling Promise, Malling Exploit and other new varieties were again supplied to research and educational units both at home and overseas. New half-acre nurseries of virus-tested stocks of Malling Promise and Malling Exploit were planted.

Field trials of raspberry varieties.

The variety trials planted at Slatefield, Forfar, in 1947, and at Pathhead, Kirriemuir, in 1949, were maintained, and yields from these are to be fully recorded in 1951. Continuity of this side of the Investigation's work has been provided for at the Scottish Horticultural Research Institute, Mylnefield, Invergowrie, by the planting of a replicated trial of the six new seedlings raised at East Malling, at present being grown as single plots in the Kirriemuir trial. Material has also been planted at Mylnefield to permit the investigation of a number of cultural practices in raspberry growing.

PUBLICATIONS DURING THE YEAR.

(See Section V, C268, C270, C275)

Part III

RESEARCH REPORTS AND REVIEWS

AMOS MEMORIAL LECTURE*

DEVELOPMENTS IN FRUIT GROWING AT HOME AND ABROAD

By T. NEAME, Esq.

The plan of the Amos Memorial being to have lectures from both the scientific and from the applied standpoint, it has fallen to my lot to be invited to talk on developments in the practice of fruit growing in England during the last 30 years in the light of a grower's impressions received during a recent visit to the United States of America and to four countries of the Commonwealth.

When I joined the family business in 1919 as a consequence of war, there were about 30 acres each of apples and pears trying to come into bearing. My father planted these trees from 1909 onwards, when there was no advisory service, no source from which he could seek guidance save friends with similar problems, nurserymen or market salesmen, although Wye was already developing the interests which led to the foundation of East Malling Research Station.

It was not unknown in those days for a would-be grower to instruct a nurseryman to supply apple trees for, say, 10 acres, with the result that anything from 3,000 to 5,000 trees of perhaps 50 different varieties might be planted in that 10 acres.

In our case, fortunately, only some 10 varieties of apples and 10 of pears were planted, first at 9 feet by 10 feet and later 12 feet square, while Bramley's Seedling were set out in that abominable form of a 15 foot triangle.

In 1919 we had one small $2\frac{1}{2}$ h.p. spraying outfit, which sufficed for the amount of spraying we did. There was then no regular spray programme ; instead, much time was spent examining the trees to see whether caterpillars were present and then discussing whether there were enough to justify a lead arsenate spray. In fact, it was considered that poultry might be a sufficient control for caterpillars and these were widely introduced for this purpose. They failed in this, but are nevertheless, I consider, a useful adjunct.

We usually applied one pre-blossom and one post-blossom Bordeaux spray on some varieties such as Worcester Pearmain apple, Clapp's Favourite pear and a few others, but scab on Bramley's Seedling was unknown. What a laborious business spraying was, creeping up and down each branch with the recommended misty spray from a single nozzle on an 8-foot lance. Apple Sucker is unknown to most modern growers, then it was a pest to reckon with. We hardly knew Capsid Bug until 1929, when we had such a serious attack that we tackled it vigorously in subsequent years and have not been seriously troubled since.

Sawfly became a real menace about 1926 and caused us very grave anxiety for a time in spite of gangs of women picking off the affected fruitlets, until the early post-blossom nicotine spray was adopted from 1932 onwards.

Apple Blossom Weevil we knew and feared, but at Macknade the damage done was never catastrophic. Scab on Bramleys appeared about the same time as Sawfly, and Red Spider came to our notice in the early thirties. We turned to lime-sulphur as a fungicide, and this controlled scab, while checking Red Spider and Apple Mildew.

In 1924 we acquired a 7 h.p. spraying machine, used higher pressures and coarser sprays and so got over the ground much faster. We even advanced to twin nozzles, to the satisfaction of our spraying gang as well as ourselves.

* The fourth Amos Memorial Lecture, delivered at East Malling Research Station on 22nd November, 1951, before an audience of over four hundred.

Some of our plantations, being old hop-gardens, had underground mains, but we found them unsatisfactory with Bordeaux, as we overlooked the simple precaution of washing out the pipes daily after use. So we moved our spraying tackle from plantation to plantation and laboriously laid out ordinary screwed and socketed 1-inch steel pipes until light-weight quick-thread pipes were introduced.

As the complexity of the spray programme increased, so it became necessary to increase the speed of application, i.e. cover a greater acreage per day, either by increasing the number of machines or by increasing the output of each machine and man. Development has taken place in two ways.

A widely adopted method was to instal a central pumping plant and underground mains, enabling each man to be supplied with as much wash as he could possibly use at as high a pressure as hoses would stand. This made it possible to spray plantations rapidly and efficiently, but entailed considerable capital outlay, particularly if plantations were widely scattered.

An alternative was developed, namely mobile spraying machines drawn by tractor through the plantations, the pumps being driven either by power-take-off or by a separate engine, with two spray men walking behind, though under some conditions it is possible for men to ride on the machine, making the work less unpleasant and arduous.

Where labour is scarce, particularly in the United States, further developments have taken place in the direction of dispensing with all men but the driver, distributing the wash through galleries of nozzles, fixed or oscillating, or by means of vertical booms of various designs. The latest development has been the " Air-Blast " type of sprayer, using air in place of hydraulic pressure. Except in the case of very large and widely spaced trees, these machines appear to do a good job of work and are now being widely used in the U.S.A. The main problem is that of keeping them supplied with wash ; some users find that they are actually spraying for less than half the working hours, whereas with underground mains a very much higher time-usage should be attained. Nevertheless, these machines cover a very large acreage in a day.

On a large Citrus farm in the Transvaal the spraying is still done from the headlands through 300 feet of hose, but native labour is cheap and application per tree very heavy. Elsewhere the mobile machine is in general use. One grower on 16 acres in New Zealand had a speed-sprayer. Rather excessive capitalization, but he got satisfaction from the fact that he could spray his whole acreage single-handed before breakfast !

In British Columbia a firm has produced a small low volume air-blast machine, delivering to one side only and able to get close to the trees. This has been adopted by a very large number of growers and is giving great satisfaction under their conditions, but Scab is not one of their problems.

Both in Canada and in the U.S.A. much research work is being done on low-volume high-concentrate sprays and is meeting with considerable success. They find that comparable results are obtained whether they use 100 gallons of a 1 per cent concentration, 50 gallons of 2 per cent or 25 gallons of 4 per cent. With these concentrated sprays, run-off is reduced, time used in refilling tanks is saved and a larger acreage covered per day. There are certain aero-dynamical difficulties to be overcome and the best size of droplet has yet to be determined, but the work being done at East Malling, Long Ashton and Silsoe will doubtless find the right answer for our conditions.

Brief reference has been made to some of the pests which have become of importance in recent years and of the mechanical methods of dealing with them. What about the chemical side ? Thirty years ago, some keen fruit growers scattered lime over their trees (an unpleasant job) or painted the trunks with lime-wash. Equally unpleasant was the caustic-soda spray used for a time.

Tar oil was just becoming known in 1922, Bordeaux or Burgundy mixtures were the most commonly used fungicides, lead arsenate the popular poison for caterpillars, with nicotine or quassia for aphids and allied pests, but growers were far from adopting the comprehensive programmes now regarded as routine.

Lime-sulphur and the so-called ' colloidal ' sulphurs have largely taken the place of Bordeaux. DDT, BHC and the new phosphorus compounds may replace lead arsenate and nicotine. Even tar oil may be relegated to a back seat, while it is possible that organic compounds, less damaging to foliage, may one day replace the older types of fungicide.

Systemic insecticides are already in use, can our fungus troubles be dealt with in the same manner ? This idea may not be entirely visionary, as organic compounds are already being tested for this purpose.

It was a shock to be told that in Washington D.C. apparently only one pre-blossom scab spray was applied, but it was explained later that while buds are still tight the ground is heavily sprayed with half per cent Elgetol. It is claimed that an application of 400 gallons per acre destroys the scab spores, but this is not successful everywhere.

A very large number of new compounds is being tested in the U.S.A., some of them, such as Dupont's EPN.300, U.S. Rubber Company's Aramite 83R and Dow's Ovotran K.6451, being particularly successful against Red Spider, one of their major problems if they can maintain their

control of Codling. Many of these are also under test in this country, not always with such good results. In the U.S.A. they have problems which we are spared, but I have always found that my list of troubles outnumbers theirs, while in many States scab is unknown.

Brilliantly as our research workers are helping us to cope with our difficulties, we still have many problems for them to solve. Firstly what may perhaps be loosely described as the " acclimatization " or " immunization " of our pests and diseases.

I well remember being able to control the hop aphid with 1½ oz. of nicotine per 100 gallons ; now at least 6 oz. are needed. It seems nowadays that more lead arsenate is needed to kill caterpillars. In Australia stockmen are finding DDT less effective against animal parasites ; in the U.S.A. the modern house-fly laughs at it. Is it a case of the survival of the most resistant strains, or are mutations taking place ? We appear to need alternative spray programmes, each as harmless as possible to our insect friends, so that if a pest survives the swings it may be done in by the round-abouts.

The apparent increase in bacterial and virus troubles is alarming. As our knowledge of the latter increases, we realize the need for a national nuclear stock scheme capable of organizing and controlling the safe custody and multiplication of virus-free fruit plants as they are isolated by the research worker. In the case of soft fruits, the propagation of these plants to quantities sufficient to meet the needs of Special Stock growers is a crucial phase, and recent work indicates that a similar need may arise in the case of other fruits.

Thus, in some respects, the difficulties facing the fruitgrower appear greater than ever before. Against this there is now a different approach to our industry. The modern grower is better informed technically than his father or grandfather, he has access to scientific and technical literature, he has an advisory service, of which he makes good use, and the programme of research work is ever being widened.

A new development is the use of hormones in controlling our crops. Those used for ' sticking-on ' the fruit shortly before the usual picking-time are already proving their worth, though more discretion in their use may be necessary in some cases. No proven palliative for inadequate fertilization or frost damage has yet been found however, and although the use of chemicals for thinning has been widely tested in America, the results obtained are often very variable. But under Western conditions the set of apples is generally so good and manual thinning so expensive to carry out that growers are greatly interested. We saw it being done in Washington with Elgetol and in Michigan with alpha-naphthalene-acetic acid, two applications sometimes being recommended. It should appeal particularly to one grower who told us he did not like too many pollinators in his plantations, as the set would be too good !

More and more attention is being given to the breeding of new varieties, and this may well be an answer to our problems. But it is a very long-term approach. While the breeder is introducing resistance to disease, he may lose some other factors of importance to the commercial grower, and there are so many. He has to consider prolific and regular cropping, uniform and adequate size of fruit, season, colour, flavour, texture and frost-resistance, to name but a few.

On the cultural side, the biggest advances, following the early work at Long Ashton and East Malling, have probably been the discovery of the need for potash, the work of Hatton and Amos on rootstocks and of Roach and Wallace in their respective spheres on trace element deficiencies.

The work on trace elements seems to become of ever greater importance. Old farmers knew that certain crops would never do well on some of their fields, no one then could tell them why.

Of recent years we have become familiar with the names of manganese and magnesium, we can recognize iron deficiency and we have learnt the danger of over application of lime, but recently we have had sprung on us, or should I say, pointed out to us, deficiencies of zinc and copper. Spraying is one form of treatment, and even foliar nutrition with urea is under trial.

In addition to our research workers we now have, what was unknown in 1919, a staff of soil chemists who not only analyse our soil samples, but examine and report on the texture and drainage of our soils and advise on their suitability for crops we may wish to grow.

But we still have much to learn about the nutrition of our trees. We can be advised of the need for potash, we are aware that nitrogen stimulates growth and that phosphorus is probably less essential, we argue about the importance of organic fertilizers, but must still rely principally on observation of the growth of the tree and our own judgment of its needs.

Pruning has been revolutionized as the result of hard experience, the work of Grubb at East Malling and the teaching of Kent, Thomson and others. Our early mentors were the gardeners whose duty it was to keep their trees tidy and their growth within bounds, with the result that wood-growth was stimulated and fruiting delayed. We now feel that the trees' duty is to bear fruit and not to grow scaffold poles, so treat them less severely.

Budding and grafting are carried on much as our ancestors did, but we have to thank Tasmania for introducing the practice of frame-grafting, when it is considered desirable to convert a useful tree

quickly from one variety to another. This has been further developed here, is widely carried out and is a great advance on the old method of cutting off large limbs and inserting two or more scions.

The work on rootstocks is so widely known that I need not enlarge on it. Thirty years ago there were firms who knew their stocks, selected those they considered the most suitable and used them. But many stocks were purchased abroad from people who were not particularly interested in what they collected, so long as they could find a buyer, with the result that growers suffered the disappointment of growing trees of very variable size, performance and life.

The rootstocks in common use having been sorted, classified and described, East Malling has now bred further series of apple stocks, which, it is hoped, will avoid the faults of existing ones and offer a wider choice to the grower. The world is being scoured also for better stocks for stone fruits and for pears.

I found everywhere that Malling stocks were known and had been tried. In some cases they were not found to be sufficiently vigorous, though M.XII or M.XVI were liked by some in Australia, New Zealand and South Africa, and M.II is becoming popular in British Columbia.

Pears seem generally to be grown on pear stocks abroad, and one grower in South Australia had spent many years in selecting a Swan's Egg pear whose seedlings are uniform. For peaches, seedling stocks are widely used because stones are readily obtainable from canneries. The same grower finds Lady Palmerston provides a very good and uniform seedling stock for peaches.

Little has so far been said about varieties of fruit, beyond the statement about the excessive number sometimes planted. Modern practice has rectified this.

Among apples older growers will remember competition classes for King of the Pippins, for Allington Pippin and others one could name. Where, except in private gardens, do we now find Stirling Castle, Annie Elizabeth, Bismarck, Gladstone, Rival and other one-time popular varieties.

Newton Wonder is still with us, though not much planted now, and Lane's Prince Albert has had to take a back seat. Bramley's Seedling has proved such a good cooking apple and free bearer that it dominates the market even before it is really fit to gather, and leaves little room even for the early varieties.

It was believed by many growers that Cox's Orange Pippin was too difficult to grow and that its proneness to canker took it out of the commercial class. Now it reigns supreme and is probably more widely planted in England than any other kind or variety of top fruit. If we can produce it regularly at a price that the general public will pay, we need fear no competition for four or five months of the year.

Worcester Pearmain was widely grown over 40 years ago and is still one of our principal commercial varieties. If not picked prematurely, but allowed to mature, it can be a very pleasant apple to eat. That it is not so second-rate as its critics make out, is proved by its continuing popularity.

Beauty of Bath is equally well-known, but would readily be replaced if a substitute for this early apple could be found. There are several attractive varieties of the same season which are only suitable for the garden.

It is tragedy to the enthusiastic grower that the public taste is so indiscriminating, and that appearance seems to be of greater importance than eating quality. Red sports occur not infrequently and, in America, are promptly propagated on a large scale because they are known to attract the public. Even the Oregon Newtown appears to be losing favour.

With new varieties the firm of Laxton Brothers has been more successful than most. Although some of their introductions are only for garden use, several have been widely planted by commercial growers. It remains to be seen how many will pass the test of time and face the competition of new introductions from East Malling, Long Ashton, the John Innes and elsewhere.

In pears, never so widely grown as apples, the casualties may not have been quite so heavy, though Conference and Laxton's Superb are tending to monopolize new plantings while Williams', known in South Africa as B.C. and in the U.S.A. as Bartlett, is staging somewhat of a come-back.

Emile d'Heyst, Beurré Diel and Marguerite Marillat are still grown, while there are growers who succeed with Beurré Hardy, but Fertility is passing out. There are many other good pears, but they are all overshadowed by that wonderful cropper Conference, which is not only a prolific bearer, but is quite a good pear to eat, has until recently been free from scab and can be readily recognized by the consumer.

I have a great liking for Doyenné du Comice. Even if not so profitable as Conference, it spreads the season and gives the grower the satisfaction of having produced a work of art.

I am watching some new varieties, but only Laxton's Superb has so far gained a foothold. Packham's Triumph is very popular in the Dominions and is a good pear, but of rather unsatisfactory shape from young trees.

Cherries, being much longer-lived, have undergone fewer changes. Some new varieties, unknown to the last generation, have gained a foothold alongside the old, but Crane's new varieties are likely to prove the biggest advance for years.

I was interested to see in New Zealand cherries, believed to be on Mahaleb stock, grown in cages as a commercial proposition. One grower in Otago had a cage of one acre of cherry trees planted 11 feet apart, which yielded in one year 2,000 10-lb. boxes, equivalent to over 800 halves per acre, and selling at one shilling and more per pound. He prunes heavily, manures heavily and mulches with pea-straw. This is chopped up later by a rotary hoe. Some of these trees are 40 years old.

Plums seemed to have changed little. The Kent Bush plum is now little planted and Czar is less popular, tar oil having made it too easy to grow, but the Pershore or Egg plum still persists. Growers are turning their thoughts more to dessert plums and late ripening varieties, of which a few promising new varieties are appearing.

But what has happened to the soft fruits we used to grow ? Red currants seem little in demand, though there are useful newer varieties, such as Red Lake, now available. In the case of black currants the popular old Baldwin is still grown, though rivalled now by Wellington XXX, the Westwick and Long Ashton varieties and others, while Amos Black, it is thought, will prove a long-lived memorial both to Amos and Tydeman. A new lease of life has been given to black currants by the control of Big Bud and consequently of Reversion. At one time, in spite of hand picking of the swollen buds, the life of a plantation was limited to very few years. Here again Amos and Hatton did great work in sorting out black currants, many stocks of which were hopelessly mixed, and exposing synonyms, whether innocent or calculated.

Among strawberries, Royal Sovereign was widely grown 30 years ago and is still unrivalled, though its continued existence as a commercial and a garden variety we owe to the labours of the virologists and the pomologists. But who grows the old favourites such as Sir Joseph Paxton, Stirling Castle or Jucunda ?

Auchincruive Climax appears likely to be very valuable to us and some of the Cambridge seedlings may be when they have undergone further trial. Several imported varieties have been tried with high hopes and have fallen by the way-side. Now, however, that we have learnt so much about our virus problems and methods of isolation, the outlook for strawberries and raspberries may be considered more cheerful. Strawberry aphid has always been difficult to control by spraying. Some success followed the use of mobile fumigators, and growers are now looking hopefully to the systemic insecticides.

The worst fate has befallen the raspberry, where the incidence and spread of virus diseases led to many old favourites becoming uneconomic. But the work of Harris and of Cadman and Wood in Scotland has opened up a new future for the crop, and some of the new varieties raised by Grubb at East Malling show great promise. Older growers were seriously perturbed by the Raspberry Beetle, but science has shown us how to control that pest and is helping us to combat the fungoid diseases.

Gooseberries seem to have fallen somewhat from favour. Leveller, a specialist's fruit, still stands unchallenged and was even given a special niche when prices were controlled, while Careless ranks as the leader for general commercial purposes, but Whinham's Industry, Crown Bob, Cousen's Seedling and others seem to be names of the past.

We ourselves gave up growing the other cane fruits many years ago, the demand for preserving appears less pressing and I have nothing to say about them further than that new hybrids appear from time to time and are tried by some growers, but do not make great headway.

Reference can here be made to the National Fruit Trials. These were started at Wisley in 1921 by the Royal Horticultural Society, which bore the expense for a number of years with some assistance from the Treasury and outside bodies. As the cost increased more assistance was given by the Treasury until finally the decision was made to relieve the R.H.S. of the work and establish the Trials on a new site less subject to the destructive frosts from which Wisley suffers. A suitable site, in Kent if possible, is urgently needed, and it is very desirable that all growers should co-operate by drawing attention to land that might become available.

These Trials were inaugurated so that growers might have the opportunity of seeing new fruit varieties tested on various stocks alongside familiar commercial varieties and of receiving reports upon their virtues and vices both at Wisley and at selected sub-stations. The reports make very interesting reading and are both a guide and a warning to growers who may be tempted to plant up new varieties as the result of a hasty first impression or the eloquence of the raiser.

The environment of the tree, bush or plant receives more consideration now than ever before. It used to be common practice to plant two, three or more kinds of top fruit together, undercrop with gooseberries or black currants and strawberries and cultivate sedulously by hand. Shortage of labour during the 1914-18 war made it impossible to maintain this clean cultivation; growers learnt that it was unnecessary, and it then became common practice to permit the growth of summer weeds. The next step was the permanent or semi-permanent sod. For some years we compared two similar plantations (mostly Bramley's Seedling apples) under permanent sod and summer weeds, respectively. The former produced as many apples of rather better quality and now we grass down at an early

stage. Obviously the growth of the cover crop must be controlled in order to avoid excessive competition with the trees, while in regions of low rainfall permanent sod may be impracticable unless irrigation is practised.

We found clean cultivation widely practised in the Dominions, summer weeds being allowed to grow or cover crops sown. Where furrow-irrigation is used, a permanent sod is clearly not feasible. But permanent sod is common in the Eastern States of the U.S.A. where rainfall permits. The damage caused by clean cultivation in hot climates through loss of humus and by erosion is becoming widely recognized, but the cost of installing spray-irrigation in place of furrows may deter growers.

In the Nelson Area of New Zealand, plantations have deen destroyed by permanent sod where irrigation was not possible.

The permanent sod is no cheaper than cultivation, but has definite advantages for spraying and picking, helps to preserve the structure of the soil, and does, we believe, minimize certain trace element deficiencies.

In Hood River, Oregon, we visited the arch-exponent of calculated neglect. The grower never cultivates, does not pick up his prunings, and applies sawdust with extra cyanamide. Neighbours criticize the untidy appearance of his 18 acre orchard, but he claims to grow 1,000 cases of pears per acre, principally Bartlett, Anjou and Bosc, and is satisfied. Spraying is done with a speed-sprayer ; although the annual rainfall is 30-35 inches, there is little summer rainfall, so he has spray-irrigation.

We were greatly interested to see the benefit apparently resulting from a hay mulch applied to ailing trees on a poor soil, whereas straw mulches had had little effect. A Cocksfoot ley was heavily manured, the grass cut and allowed to wilt and then carted direct to the trees.

My tour was planned to enable me to study the practice of irrigation in many different areas. We have all read of the great schemes of irrigation introduced in Egypt, India, etc., and of the immense increase in food production that resulted. We are all aware that this was practised in the fruit-growing areas of Africa, Australia and North America, but I confess I had not realized the complete and utter dependence of these industries on irrigation.

I have seen vines growing in the Karroo in South Africa, where the rainfall may be 1-2 inches per annum and vegetation hardly exists, but where water brought 20 miles in a canal from the hills enables one man to grow 400,000 vines.

In Rhodesia I visited a 50,000 acre farm. They grow 700 acres of citrus and 2,000 acres of maize, but much of their land is too rocky or too far from water. They are fortunate in being able to dam a nearby river and indulge in basin-irrigation for the citrus. But here it is necessary to contour all the land to prevent erosion. When it rains it rains torrentially and usually at the wrong time of year. An afternoon visit to one farm had to be cancelled because 4 inches of rain had fallen that morning, and made the road impassable. On the stock farms streams are dammed to conserve all the water possible, but an annual evaporation of 7 feet per annum detracts somewhat from their value. Annual rainfall is very variable and eight winter months may be completely dry. Where irrigation is not possible, the system of agriculture is determined by the amount of rain and whether it comes in summer or winter.

Elevation is, of course, important. In Kenya, where one may ascend or descend several thousand feet in a morning's drive, the type of agriculture and the time of harvest continually change. The limitations imposed by day length and by absence of winter-cooling are impressive. At Molo, near the Equator, at an elevation of 8,500 feet, Royal Sovereign strawberries make poor growth and do not develop runners. Of apples, only Bramley's Seedling and Blenheim Orange make any headway, but pears and some Japanese plums do better. Most English flowers, however, grow well, but 50 miles away and 2,000 feet lower they have a hard struggle.

In Australia the value and the dangers of irrigation were impressively illustrated. In one area near Melbourne with a rainfall of 30-40 inches, fruit and vegetables can be readily grown, but in most places the rain is seasonal, in some areas falling principally in the summer months, in others in the winter months. Their climate is even odder than ours. One day in Melbourne we had a temperature of 104° F. in the shade. The next day the temperature dropped about 40°, we had 4 inches of rain and a 70 m.p.h. gale.

The Shepparton fruit area in Victoria was developed after the 1914-18 war, being financed by the State. Water was diverted from the River Goulbourn, and freely used by the ex-service settlers. An immense fruit industry was built up, but in places the water-table has been considerably raised, salts brought to the surface and the texture of the soil destroyed. Water should be applied reasonably, say 3 inches at a time, and adequate drainage provided.

Now a large area at Loxton is under development for ex-service men of the last war. Immense effort and expenditure are being devoted to detailed topographical and soil surveys, to the construction of water channels, fences and houses. So thorough is this that the settler is told how his water-furrows should run, what kinds of fruit he should grow and even which parts should be furrow- and

which spray-irrigated. The very large capital outlay is shared by the Federal and the State Governments. The settler is required to have had considerable practical experience, and is paid a weekly wage until his fruit trees come into bearing. The value of his holding is then assessed and he is debited with this amount, to be repaid over a period of years. It is realized that the assessed value will not cover the outlay incurred, but the investment is nevertheless regarded as a good one.

New Zealand is often regarded as the land where cows get their living from pasture all the year round, in consequence of abundant sunshine and rain. This is only partly true ; irrigation is practised both in the Hastings and Nelson areas, and is essential in Central Otago where the rainfall is only about 10 inches. This is due to the central mountain range, which traps the Westerly winds from the Tasman Sea and causes an annual precipitation in the West of 100 inches or more. Otago was an important gold-producing area, and when the gold was exhausted the prospectors turned to fruit growing, using the old water-races for irrigation. It has been found that apricots thrive best in gold-bearing areas, but peaches and apples are also grown there.

In British Columbia and the Western States of America rainfall inland is inadequate, so irrigation is general, mostly by furrow, but sprinkler-irrigation is being adopted by some growers who wish to avoid erosion and enjoy a gentler form of application.

At Sacramento the average annual rainfall is 16-18 inches, though it has varied from 9-45 inches. On this good very deep soil there was, for many years, no response to fertilizers and their apricots generally get through the summer without irrigation, but they consider it necessary to irrigate after picking.

It was of particular interest to find that even in Michigan, with a rainfall of around 35 inches, many growers are adopting irrigation, as they always expect at least one dry summer month. This strengthens my own feeling that many fruit areas in England might benefit from irrigation. I have seen in Africa and in New Zealand as much as 12 inches of water used in one application for fruit and for hops, but this was clearly extravagant and some of it escaped from the ends of the irrigation furrows. We gathered that 3 inches was a suitable application at one time, repeated as necessary. We must remember, however, that in their climates evaporation and transpiration losses are higher than in England, so 2 inches may be adequate for our conditions.

Reference has already been made to early mistakes in close planting and this question of planting distance is a lively topic of discussion whenever growers meet. It is now fairly generally accepted that a wide plant should give as good or a better nett cash return per acre than an over-close plant and has advantages in respect of cultural operations, but there is as yet no agreement about the wisdom or otherwise of having filler trees during the early years of the life of a plantation. Trials we are carrying out may, in 10 or 15 years' time, provide some interesting data on the economics of the two systems.

It used to be common practice to plant mixed orchards containing apples, pears, plums and even cherries. The idea possibly was that, if one kind of fruit failed in any particular year, others might crop and some revenue be obtained. This may have worked satisfactorily when pests were less in evidence and quality less important. It is now regarded as not very practical, largely owing to the very complete spraying programme now found necessary and the difficulty of accommodating this to different kinds and different varieties of fruit. Diversity of enterprise or specialization are matters of controversy. In many places visited, years of experience have demonstrated that one kind of fruit does better than all others and growers have concentrated on that, i.e. apples in the Okanagan Valley, pears round Medford, grapes in certain parts of the Australian Riverina and so on. Climate, soil and water supply are the determining factors, but market facilities, such as a nearby cannery, must also affect the choice. One grower near Auckland had apples, peaches, lemons, oranges and grape fruit, and claimed to be picking and marketing fruit for 50 weeks in the year from his 12½ acres.

In New Zealand, holdings from 4½ acres upwards are quite common. The owner does most of the work ; he may have one or two regular men and relies on migrant labour for picking.

By way of contrast we visited a grower in Australia who had 400 acres of pears, but he told us he would be happier with 5 acres owing to labour shortage. And in California we drove for three miles through one plantation of peaches and figs. In the older fruit areas of England, on the other hand, growers generally have several kinds of fruit, but in the newer areas there has been a tendency to specialize in apples.

In California, oil spraying for weed control has been practised for 25 years and now 25,000 acres are kept clean in this way. Provided well water is used, no oil is needed after three years, only an occasional walk round with a hoe.

California, we were told, produces 45-50 per cent of all the fruit grown in the U.S.A. with 25 per cent of all the fruit trees. A crop of 45 tons per acre of Beurré Hardy pears, without fertilizers, has been recorded in this wonderful district.

We found these reports of heavy crops rather depressing, but it was explained to us that they can

rely on ample sunshine and rain does not concern them, as they apply what water is needed. Without these heavy crops they could not carry on, they are so far from markets that transport costs levy a heavy toll and a large portion of their crops is canned. I cannot think we are likely to be able to compete with American canned peaches or pears when the dollar problem is solved.

Damage by frost is a problem ever present in growers' minds. In 1920 the problem had not arisen in an acute form. We all remember what we suffered in 1935 and 1938, and subsequent years. Before 1935 I can remember 1928 as disastrous, but only one other year when serious damage occurred. This should be remembered by young growers when they criticize their predecessors for planting fruit in what are now regarded as frost pockets.

Artificial smoke clouds have been tried and experiments are being made with powerful overhead fans, but with very limited success so far. It has been found that spraying with water during the hours of frost will protect fruit buds from damage, but the amount of water needed may have deleterious effects on our soil and the necessary plant may be expensive. Fire-pots are a palliative up to a point, but are objectionable near inhabited areas. Even a site safe from radiation frosts may suffer from a wind frost, while late-blossoming varieties may suffer from a late frost, so the best line of research would appear to be that of breeding hardier varieties, but for the fact that the range of spring hardiness so far discovered in top fruits is small.

One of the greatest advances has been in the presentation of our fruit and that includes the picking, storage, grading, packing and distribution. This has to be done in the best possible manner, but with due regard to cost, which has become appallingly high.

Picking is probably done now with greater care, but the problem of transferring fruit from the tree to the store economically and without damage is not yet completely solved, while that of reducing loss from fruit-rots both in field and store merits still further attention. Progress in grading and packing received a severe set-back during the war years under the system of price control, and has been handicapped since by the shortage of materials. Most of us long to resume the use of the non-returnable package, largely a post-1918 development, but materials are becoming ever more scarce and costly. There were then very few growers attempting box-packing of apples or pears, and even fewer understood much about it, as the exhibits at the Crystal Palace Fruit Show testified, but overseas competition and the efforts of men like Joe Stoddart brought the B.S.A. box into relatively common use for apples and pears, and the chip basket for soft fruits. Barrels and wicker baskets were previously the generally accepted package, and even strawberries at one time went to market in wicker baskets. How galling it is now to hear the presentation of our fruit criticized and that of foreign fruit praised, when our planned economy prevents the purchase of the necessary materials except when surrounding imported fruit.

Graders were few and far between, and grading little practised; it would have interfered with the all too common practice of topping the package with the best specimens. It is grieving to know that this ignorant and short-sighted practice, though now rare, is still occasionally to be seen. The necessity for grading machines is now generally recognized, though the rival merits of size grading and weight grading are still a matter for argument.

Cold storage by the grower was in its infancy ; I believe Spencer Mount was the pioneer in this respect. In 1924, when we erected a cold store, there were still so few that the market for small Bramleys at the end of the season was most rewarding. In 1930 the D.S.I.R. Laboratory at Ditton was built, partly to solve the problems of the Dominion growers supplying our market, but in view of the tendency of Bramley's Seedling to low-temperature break-down special attention was given to this variety. Refrigerated storage in controlled atmospheres or gas storage, as we know it, was the outcome and this has been of immense assistance to us in marketing our fruit.

Gas storage has been little used overseas, though I saw a most interesting store in Cape Province, entirely encased in an air-tight steel shell with foam concrete lining. The shell was of concertina form to allow for expansion. The cooling was by overhead grids without a fan, but the engineer said a fan would be desirable to ensure circulation of the CO_2. He appeared to think that the oxygen content was of more importance than the percentage of CO_2.

In British Columbia we visited a modern packhouse with four cold chambers, each 76 feet by 115 feet, with a capacity of 75,000 bushels. Another new packhouse near Wenatchee had four large storage chambers 70 feet across, each of 110,000 bushels capacity. In the West and Mid-West, Cutler graders are in general use ; here there were two with 42 bins each side with a throughput of 6,000 bushels per day. They can load 12,000 boxes a day into cold store, and bring the temperature down in 24 hours. Here, too, they depend on pallets and fork trucks. In one 12-hour day, two men took in from lorries 27,000 boxes.

Some reference must be made to the actual selling of fruit. Our present system of consignment to Commission Salesmen in wholesale markets in the large cities has developed over the years, has stood the test of time and proved an expeditious and efficient way of getting fruit from the grower to

the retailer. These markets have such a turnover that they can absorb daily variations in arrivals in a way impossible to the smaller markets. The latter rely to some extent on local produce, partly on consignments from the main growing areas, and, for the balance, on re-consignments from larger markets. Where no wholesale market exists within reach, retailers must rely on a local secondary wholesaler to supply their needs.

Auction markets may be suitable under some circumstances for some areas, but I fail to see how they can transfer produce from the grower to the retailer any more efficiently than the present system. How can the retailer find time to attend auction sales and wait until the auctioneer gets to the particular lot he wants ? He will have to employ another intermediary to buy for him at an unknown price instead of dealing direct with the salesman.

I suggest a better course, instead of erecting new markets, is to encourage the building of co-operative packhouses which will lead to improved standardization, to transport in bulk at cheaper rates and to easier and speedier selling. Low grade produce could also be disposed of direct to processors instead of cluttering up and depressing wholesale markets.

Most of the fruit areas visited overseas were very long distances from consuming markets, and this circumstance has driven growers to market co-operatively. Grading and packing may be done by the individual grower, as in New Zealand, or by private firms of packers or by co-operatively owned packhouses, as is general in Canada and Western U.S.A. subject to close Government inspection.

Circumstances may lead us along the same path, but some protection, as they have overseas, from unfair and subsidized competition, would appear to be necessary, if our industry is to maintain its position and provide the livelihood which efficient growers deserve.

Lastly, I should like to record that my connection with East Malling Research Station proved to be an ' open sesame ' wherever we went, and to express my appreciation of the warm welcome and ready co-operation extended to us by research workers and growers everywhere.

The work of the Station is known and valued throughout the world, and the liveliest interest was displayed in all we are doing.

I cannot close without reference to the work of the man whose career inspired these lectures. The quality in Jesse Amos that stood out was his knowledge and understanding of the plant.

Pest and disease control by chemical means appears to be an unavoidable part of our industry, but above all, to produce crops adequate to keep us in business, we must know our trees and supply the environment and treatment that seem necessary to maintain them in a healthy growing condition.

POMOLOGY

THE INFLUENCE OF THE POLLEN PARENT ON THE DEVELOPMENT OF APPLE FRUITS

By H. M. TYDEMAN

Introduction.

Experiments have been carried out during 1950 and 1951 to determine whether Cox's Orange Pippin apples were influenced by their pollen parent. Earlier observations on this subject, made in the course of apple breeding experiments, were largely inconclusive, but considerable differences in size between apple and pear fruitlets differently pollinated were found during the earlier stages of their growth (Tydeman, 1938, 1944).

Forty trees of Cox's Orange Pippin on M.IX, approximately 20 years old and previously grown as cordons, were transplanted into pots during the early part of 1950. The flowers were emasculated and the pollens applied in an insect-proof greenhouse. Calliper measurements of the diameters of all the fruits were made at fortnightly intervals and their weights and seed content recorded at maturity.

Preliminary experiments, 1950.

In 1950 approximately 26,000 flowers were emasculated on 39 trees and impregnated with pollen of one of the four varieties, King of the Pippins, Ellison's Orange, James Grieve and Worcester Pearmain. There was good initial set, but a severe fruit drop, possibly the result of using recently potted trees, reduced the value of the later comparisons. However, seven weeks after pollination there was a considerable difference, significant at above the 1 per cent level, between the mean diameter of fruits pollinated by King of the Pippins and of those pollinated by Worcester Pearmain. The mean fruit diameters at the end of the fifth, seventh and ninth weeks are given in Table I.

TABLE I.

MEAN DIAMETER OF COX'S ORANGE PIPPIN APPLES, 1950.

Weeks after pollination.	Pollen Parent.				*Significant difference. $P = 0{\cdot}05$.*
	King of the Pippins. mm.	Ellison's Orange. mm.	James Grieve. mm.	Worcester Pearmain. mm.	
5	13·8	13·4	13·2	12·7	*N.S.*
7	22·6	21·7	21·0	20·7	*1·0*
9	30·1	27·7	26·2	26·8	*3·8*

N.S. = parentage effects not significant at the 5 per cent level.

No significant differences in fruit size were recorded at later stages of development, due perhaps to the great variability of the surviving fruits. Only slight differences in the number and weight of the seeds in mature fruits were found, while tests carried out at the Ditton Laboratory of the D.S.I.R. failed to show any differences either in rate of respiration or the date of the climacteric that could be attributed to the influence of the pollen parent.

Main experiments, 1951.

In 1951 the 40 trees of Cox's Orange Pippin, now well established, were used as seed parents. To simplify the work of emasculation and pollination, the trees were brought into the orchard house in batches of 10 at monthly intervals from the end of December onwards. This treatment resulted in a difference of from 7 to 18 days in the time of flowering of successive batches. Approximately 14,000 flowers were fertilized with pollen of King of the Pippins, Worcester Pearmain or Miller's Seedling. As the central or 'king' fruits are frequently found to be abnormal in their development, the central flower in each truss was removed. On half the trees the young fruitlets were sprayed with a commercial preparation of α-naphthalene-acetic acid at five parts per million,

three weeks after pollination, as a precaution against excessive fruit drop. Good sets were obtained on both the unsprayed and the sprayed trees and there was no evidence that, under the special conditions of this experiment, the spray had exerted any effect upon the degree of subsequent fruit drop. A significantly better initial set was obtained where King of the Pippins or Miller's Seedling was the pollinating variety. The difference in fruit number persisted throughout the experiment.

The results of fortnightly measurements of fruit diameter from the end of the third until the end of the fifteenth week after pollination are summarized in Table II. Data from the four batches of ten trees pollinated at successive intervals have been pooled, there being no evidence of any significant interaction between the pollen treatments and the time of application. The effect of varying times of pollination upon the development and time of maturity of these fruits is discussed elsewhere (Tydeman, 1952).

TABLE II.

MEAN DIAMETERS OF COX'S ORANGE PIPPIN APPLES, UNSPRAYED GROUP, 1951.

Weeks after pollination.	Pollen Parent.						*Significant Difference. P = 0·05*
	King of the Pippins.		Miller's Seedling.		Worcester Pearmain.		
	Fruits.	Diameter mm.	Fruits.	Diameter mm.	Fruits.	Diameter mm.	
3	1063	**9·3**	1222	**9·2**	1047	**9·0**	*N.S.*
5	643	**17·9**	793	**17·2**	707	**16·9**	*0·40*
7	381	**26·1**	448	**25·6**	377	**24·6**	*0·59*
9	302	**32·4**	346	**31·7**	260	**30·8**	*0·67*
11	276	**38·7**	310	**38·2**	219	**37·5**	*0·78*
13	272	**45·1**	308	**44·9**	217	**44·1**	*N.S.*
15	270	**50·0**	304	**49·5**	216	**48·8**	*0·91*
Number of flowers pollinated :	2391		2437		2468		

N.S. = parentage effects not significant at the 5 per cent level.

Although all the fruits were picked at approximately the same time, those of each group of ten trees were of different ages since, on the average, 148, 141, 130 and 117 days had elapsed since each group of flowers were pollinated. The mean values for fruit diameter in Table II are for the unsprayed trees and have not been given beyond the fifteenth week in order to include only data from all four groups.

These trees showed a significant difference between the mean diameter of fruits having King of the Pippins as pollen parent and those having Worcester Pearmain throughout almost the whole course of development. The difference was greatest from seven to nine weeks after pollination, when it amounted to between 5 and 6 per cent of the mean with a significance well above the 1 per cent level. It tended to decrease thereafter, but was still significant ($P=0·05$) at the end of the

TABLE III.

MEAN DIAMETERS OF COX'S ORANGE PIPPIN APPLES, SPRAYED GROUP, 1951.

Weeks after pollination.	Pollen Parent.						*Significant Difference P = 0·05.*
	King of the Pippins.		Miller's Seedling.		Worcester Pearmain.		
	Fruits.	Diameter mm.	Fruits.	Diameter mm.	Fruits.	Diameter mm.	
3	1095	**10·3**	1176	**10·1**	1025	**10·0**	*0·14*
5	629	**17·4**	684	**17·6**	612	**17·7**	*N.S.*
7	302	**25·8**	363	**25·5**	341	**25·2**	*N.S.*
9	238	**33·2**	272	**32·7**	238	**32·2**	*0·71*
11	218	**40·3**	239	**40·1**	205	**39·7**	*N.S.*
13	211	**46·8**	233	**46·7**	197	**46·3**	*N.S.*
15	210	**51·4**	233	**51·4**	195	**50·9**	*N.S.*
Number of flowers pollinated :	2084		2159		2103		

N.S. = parentage effects not significant at the 5 per cent level.

fifteenth week. Fruits having Miller's Seedling as pollen parent occupied an intermediate position, the differences being only occasionally significant.

Where the trees had been sprayed against fruit drop the indications of an influence of the pollen parent upon fruit size were much less conclusive (Table III). There were significant differences in mean diameter between fruits pollinated by King of the Pippins and those pollinated by Worcester Pearmain only at a very early stage of development and again at the end of the ninth week after pollination, although the same trend is observable as in the data from the unsprayed trees.

There was a considerable natural 'drop' during the earlier period of fruit development (cf. Tables II and III), and only about one-fifth to one-quarter of the fruits present on the tree three weeks after pollination survived to reach maturity. As the individual fruits were not labelled before the end of the seventh week, it is not possible to trace their development in detail prior to this, but, between the seventh and ninth weeks, the fruits that were to be shed were, on the average, considerably smaller than the remaining fruits.

The mean diameters, from the seventh week until the fifteenth week, of those fruits that reached maturity are given in Table IV, from which it will be seen that they were larger than the general population of fruits upon the trees at the same ages especially at the earlier stages (cf. Tables II and III). The effects of the pollen parent on the mean diameters shown in Table IV were significant only

TABLE IV.

MEAN DIAMETERS OF COX'S ORANGE PIPPIN APPLES THAT REMAINED UNTIL MATURITY, 1951.

Weeks after pollination.	Unsprayed group.				Sprayed group.			
	King of the Pippins mm.	Miller's Seedling mm.	Worcester Pearmain mm.	*Significant difference P = 0·05*	King of the Pippins mm.	Miller's Seedling mm.	Worcester Pearmain mm.	*Significant difference P = 0·05.*
7	26·8	26·5	26·2	*N.S.*	27·2	27·2	26·8	*N.S.*
9	32·8	32·1	31·7	*0·66*	33·5	33·3	33·1	*N.S.*
11	38·8	38·2	37·8	*N.S.*	40·4	40·2	40·0	*N.S.*
13	45·2	44·6	44·1	*N.S.*	46·8	46·5	46·4	*N.S.*
15	50·1	49·5	49·0	*N.S.*	51·9	51·7	51·5	*N.S.*
Mean weight at picking in grams.	79·9	77·1	74·1	*4·27*	86·0	88·1	85·0	*N.S.*
Final number of fruits.	268	304	208		203	231	194	

N.S. = parentage effects not significant at the 5 per cent level.

in the case of the unsprayed group at the end of the ninth week after pollination ($P=0·01$); they were not significant at any stage in the case of the sprayed group.

It seems that the loss of the smaller fruits during the earlier stages of development tended to reduce the difference due to the pollen parent. It is apparent from Table IV, however, that even after these

TABLE V.

NUMBER AND FRESH WEIGHT OF SEEDS PER FRUIT, 1951.

Pollen parent.	Unsprayed group.				Sprayed group.			
	Number of fruits.	Mean number of seeds.		Mean weight of seeds mg.	Number of fruits.	Mean number of seeds.		Mean weight of seeds mg.
		Good.	Poor.			Good.	Poor.	
King of the Pippins.	268	6·3	1·0	300·5	203	6·4	0·9	292·8
Miller's Seedling.	304	6·4	1·0	287·6	231	6·0	1·2	274·7
Worcester Pearmain.	208	6·2	0·9	270·2	194	5·9	1·1	261·5
Significant difference, P = 0·05	—	—	—	*21·5*	—	—	—	*24·3*

modifications had occurred in the mean sizes of the fruits remaining on the trees, there was a significant difference of 7·6 per cent of the mean between the average weights of apples originating from King of the Pippins and from Worcester Pearmain pollen. This difference was not apparent where α-naphthalene-acetic acid spray had been applied.

The results of an examination of the seed content of the fruits are summarized in Table V. There was very little difference in seed number between fruits derived from King of the Pippins pollen and those derived from Worcester Pearmain pollen in either the sprayed or the unsprayed groups, but the influence of the pollen parent used was observable in the weight of the seeds per fruit.

The embryos were excised from the seeds in samples of 192 fruits per treatment; the mean weights of the embryos are shown in Table VI. The differences were small and not significant. At the same time there were indications of a correlation between the weight of the fruit and the weight of the embryos in the seeds. Between fruits within individual trees and pollen treatments the correlations for embryo weight on fruit weight, though low, were significant (r=0·46 for the unsprayed trees and 0·40 for sprayed trees).

TABLE VI.

MEAN DRY WEIGHT OF EMBRYOS IN MILLIGRAMS.

Pollen parent.	King of the Pippins.	Miller's Seedling.	Worcester Pearmain.
Unsprayed	83·1	81·7	81·1
Sprayed	81·3	84·0	84·9

The apples harvested were examined at the Ditton Laboratory as in 1950. The results obtained again showed no significant differences in the respiration rates or the time of the onset of the climacteric. The methods employed were similar to those described by Griffiths, Potter and Hulme (1950).

The fruits were carefully compared for colour and, as far as possible, for quality. No evidence was found suggesting that any one of the pollens used had resulted in fruits of better quality than the others.

Discussion.

Instances of the effect of the pollen upon the maternal tissues of the fruit, now often referred to as 'metaxenia', have been reported from many sources. The phenomenon is discussed in detail by Crane and Lawrence (1938), while an extensive literature upon the subject is summarized by Crane and Brown (1942). One of the most striking instances among apples is that reported by Nebel (1936), who found marked differences in the storage breakdown of McIntosh Red apples pollinated by Wilson's Red June and Boiken. No such indications were found in the experiments described here.

It is probable that the observed differences in fruit diameter and weight were to a large extent a reflection of a relationship between these characters and the weight of the seeds in the fruit. Among open pollinated fruits of Cox's Orange Pippin, the writer found (Tydeman, 1944) a relation between the size of the fruits and the number of seeds they contained, particularly among the fruits shed during the June drop and also that such fruits contained fewer seeds than the fruits that remained on the trees.

An interesting aspect of the data is the evidence that the application of α-naphthalene-acetic acid may reduce or mask the response of the fruit to such factors.

Acknowledgements.

The writer gratefully acknowledges the important contribution made by Dr. R. G. Tomkins and the staff of the Ditton Laboratory of the D.S.I.R., and the advice and encouragement of Dr. F. R. Tubbs in these investigations, together with the great assistance of Dr. S. C. Pearce and Mr. G. H. Freeman in developing the statistical aspects of the work.

Summary.

Significant differences in size were found between Cox's Orange Pippin apples derived from pollen of King of the Pippins and Worcester Pearmain during 1950 and 1951. Fruits pollinated by Ellison's Orange and James Grieve in 1950, and those pollinated by Miller's Seedling in 1951 were generally intermediate in size. The application of α-naphthalene-acetic acid considerably reduced these differences.

In 1951, on the unsprayed trees, the differences in fruit size between the three pollen varieties were generally greater where all the fruits on the tree were considered than where only those that reached maturity were taken into account.

Apples with King of the Pippins as pollen parent were significantly heavier at maturity than those with Worcester Pearmain in the group which did not receive the α-naphthalene-acetic acid spray ; irrespective of the latter treatment, there was a significantly greater weight of seeds in fruits derived from King of the Pippins than in those derived from Worcester Pearmain. Although no significant differences in the weight of the dried embryos were found there was evidence of a positive correlation between the weight of the embryos and the weight of the fruits.

No effects upon time of maturity or fruit quality were detected.

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THE EFFECT OF THE TIME OF POLLINATION ON FRUIT DEVELOPMENT AND MATURITY IN COX'S ORANGE PIPPIN APPLES

By H. M. TYDEMAN

In the course of experiments undertaken during 1950 and 1951 to test the effect of different pollens on the growth of Cox's Orange Pippin apples, it became necessary to spread the time of the application of the pollens to the flowers over an extended period. The trees were brought into blossom in successive groups in an orchard house and, as all the pollens involved were applied to each group, the method did not affect the validity of comparisons between them while it greatly increased the number of pollinations that could be made. The main experiments are described elsewhere in this Report (Tydeman, 1952).

Preliminary experiments, 1950.

In 1950, 39 trees of Cox's Orange Pippin were flowered in three successive groups, each comprising 13 trees. The pollens were applied to the emasculated flowers of the first group on 30th March, and to those of the last on 20th April. The fruits were picked on 15th August when there was less than 4 millimetres difference in mean diameter and 12 grammes in mean weight between fruits pollinated at the earlier and the later date. Fruits from each group were examined at the Ditton Laboratory of the D.S.I.R. ; no appreciable differences were observed either in respiration rates or in the times of the onset of the climacteric.

Main experiments, 1951.

In 1951, 40 trees of Cox's Orange Pippin were flowered in four successive groups and pollinated with three varieties of pollen. The dates upon which they were pollinated extended over a period of 37 days. The fruits on half the trees in each group were sprayed at the end of the third week after pollination with a commercial preparation for the prevention of excessive fruit drop. A satisfactory set of fruit was obtained on all the trees and the spray did not appear to have greatly affected the extent of the fruit drop at the concentration that was used. As both sets of trees behaved very similarly, only the results from the unsprayed trees are dealt with here.

The mean diameters of the fruits at fortnightly intervals from the end of the third week after pollination and also the dates upon which the observations were made are shown in Table I. Owing to the large numbers of fruitlets in the earlier stages of the experiments it was found necessary to spread the work of measuring them over several days ; the data shown for the third and fifth weeks have been corrected statistically to allow for this fact.

The outstanding feature during the earlier stages of development of the fruits was the relatively rapid increase in size of those resulting from the later pollinations. For example, by the end of the third week after pollination, there was a difference in diameter amounting to about 40 per cent of their mean between the fruits of the first group, pollinated on 14th March, and those of the last group, pollinated on 20th April. Thereafter, all the fruits, irrespective of time of pollination, increased in diameter by approximately the same amount with the result that, by the end of the fifteenth week, the fruits in the fourth group exceeded those in the first group by an amount only very slightly greater than that by which they had exceeded them at the end of the third week. Owing to the growth of the fruits in the meantime, however, this represented only about 10 per cent of the mean by the end of the fifteenth week.

By early August, when the fruits were all harvested, the earlier pollinated fruits were not significantly heavier than those pollinated later. There was a considerable natural fruit drop throughout the earlier stages of the experiments and this considerably affected the mean size relations of the fruits as between one group and another. The mean diameters of the fruits that survived on the trees until the end of the experiments are shown in Table II from the seventh week after pollination, when the fruits were labelled individually. The differences between the earlier and later pollinated groups were smaller than in Table I although, as between the first two groups and the last two, the differences were significant at the 5 per cent level until the end of the fifteenth week after pollination.

TABLE I.

GROWTH OF COX'S ORANGE PIPPIN FRUITS POLLINATED AT DIFFERENT TIMES, 1951.

Group.	I.		II.		III.		IV.		
Date of pollination.	14th March.		21st March.		8th April.		20th April.		
Weeks after pollination.	Date.	Mean diameter. mm.	Date.	Mean diameter. mm.	Date.	Mean diameter. mm.	Date.	Mean diameter. mm.	*Significant difference. P=0·05.*
3	5th April	**7·0**	12th April	**7·5**	30th April	**11·2**	12th May	**11·0**	*1·49*
5	19th ,,	**14·2**	26th ,,	**15·2**	14th May	**20·4**	26th ,,	**19·3**	*2·52*
7	2nd May	**22·3**	9th May	**22·5**	27th ,,	**29·0**	8th June	**27·8**	*1·85*
9	16th ,,	**28·3**	23rd ,,	**28·3**	10th June	**35·6**	22nd ,,	**34·3**	*2·15*
11	30th ,,	**35·3**	6th June	**35·5**	24th ,,	**40·8**	6th July	**41·0**	*2·76*
13	13th June	**43·0**	20th ,,	**41·6**	8th July	**46·4**	20th ,,	**47·8**	*3·03*
15	27th ,,	**47·1**	4th July	**46·7**	22nd ,,	**51·5**	3rd Aug.	**52·4**	*3·50*
17	11th July	**52·9**	18th ,,	**51·8**	5th Aug.	**55·7**	—	—	*N.S.*
19	25th ,,	**57·6**	1st Aug.	**55·5**	—	—	—	—	*N.S.*
21	8th Aug.	**61·4**	—	—	—	—	—	—	—
Mean weight at time of picking. Grammes.	9th Aug.	**88·7**	10th Aug.	**75·3**	13th Aug.	**76·4**	13th Aug.	**67·5**	*N.S.*

N.S. = Differences not significant at 5 per cent level.

As the fruits destined to drop could not be identified on the trees before the end of the seventh week after pollination, and the drop had virtually ceased in the third and fourth groups by the end of the ninth week, it is not possible to determine in detail how the fruit drop affected the mean size relations of the fruits in the different groups.

TABLE II.

MEAN DIAMETERS OF FRUITS REACHING MATURITY.

Weeks after pollination.	Group I. mm.	Group II. mm.	Group III. mm.	Group IV. mm.	*Significant difference. P=0·05.*
7	24·2	24·2	29·3	28·4	*1·46*
9	29·4	29·5	35·6	34·4	*1·80*
11	35·6	35·6	40·8	41·0	*2·68*
13	42·6	41·6	46·4	47·9	*3·00*
15	47·2	46·8	51·5	52·5	*3·48*
17	52·9	51·9	55·7	—	*N.S.*
19	57·6	55·5	—	—	*N.S.*
Number of fruits.	114	223	235	208	

N.S. = Differences not significant at the 5 per cent level.

The mean number and weight of the seeds contained by the fruits are shown in Table III.

TABLE III.

MEAN NUMBER AND WEIGHT OF SEEDS PER FRUIT.

Group.	Number of fruits.	Number of seeds.		Total weight of seeds per fruit in mg.
		Good.	Poor.	
I	114	6·1	0·7	270·8
II	223	5·8	1·4	249·4
III	235	6·3	0·8	289·0
IV	208	7·1	0·9	335·2

Although there was a somewhat greater number and weight of seeds in the later pollinated fruits, the difference in weight was not significant at the 5 per cent level. The embryos were excised from the seeds in a sample of the fruits ; the dry weights did not differ significantly.

After picking, samples of 36 fruits from each of the four waves were examined at the Ditton Laboratory. The initial rates of respiration, the time of the onset of the climacteric, and the extent of the rise in respiration at the climacteric were found to be very similar in all the samples.

Discussion.

In these experiments, apple fruits derived from flowers pollinated over an interval of 37 days appear to have reached maturity, as shown by respiration rate at the climacteric, at much the same time. The great initial disparity in size between the fruitlets resulting from the early and late pollinations did not diminish in absolute amount during growth, but became relatively less as the fruits increased in size at an approximately equal rate. The more rapid growth of the later pollinated fruits during the first three weeks after pollination remains, however, unexplained although it is possible that it was due to differences in temperature and there are indications that it may not be entirely unconnected with the number of seeds developing. It is known that the growth of the apple fruit is divided into a phase of cell division which occurs relatively early in its history and a later phase of cell enlargement (Tetley, 1930), and it may be conjectured that the later pollination was associated with a more rapid increase in cell number.

Acknowledgements.

Thanks are due to Dr. R. G. Tomkins and the staff of the Ditton Laboratory of the D.S.I.R. for their very helpful collaboration.

Summary.

In 1951, 40 trees of Cox's Orange Pippin were flowered and pollinated with three varieties of pollen under glass in four groups between 14th March and 20th April. By the end of their third week following pollination, fruits from the later pollinated flowers were larger than those from the eariler pollinated flowers by about 40 per cent of the mean.

Thereafter, until they reached maturity, all the fruits increased in diameter at the same mean rate and the relative difference in size between them was considerably reduced. The differences in mean weight between the four groups of fruits when mature were not large enough to be significant at the 5 per cent level.

Fruits from the later pollinated flowers had a slightly greater number and weight of seeds and of embryos, but in no case was the difference large enough to be significant.

Samples of mature fruits examined at the Ditton Laboratory were very similar in their initial rates of respiration, the time of the onset of the climacteric, and the extent of the rise in respiration at the climacteric.

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A STUDY OF THE BARK-WOOD RELATIONSHIP IN APPLE STEMS*

By BARBARA MOSSE

Introduction.

Beakbane and others have shown that there is a clear relationship between the histological structure of the roots of the clonal Malling apple rootstocks and the vigour which they impart to scion varieties grafted on them. It was found that a high proportion of bark in the roots was characteristic of those rootstocks which induced dwarfness and early fruiting in the scion. If dwarfness and precocity are correlated with structure, it is possible that the structure of the scion stem may itself be modified as a result of rootstock influence. Colby (1935) observed that in stems of the variety Wealthy growing on the dwarfing rootstock M.IX the bark was wider than in stems of the same variety on the vigorous rootstock M.XII. The present paper describes the work which has led to the conclusion that in certain apple varieties the bark percentage of the scion stem is influenced by the rootstock on which it is growing, and that the change is in the direction of the rootstock structure, i.e. a scion variety on a rootstock with a high bark percentage will have relatively more bark to wood than the same variety on a rootstock with a low bark percentage.

Material.

A wide range of material was examined, including stems* of both scion and rootstock varieties, from trees of varying ages, subject to different methods of pruning. Most of the observations were made on the variety Cox's Orange Pippin, which is widely used in rootstock trials at the Station, and on the vigorous variety Bramley's Seedling. Further observations were made on the less vigorous variety Lane's Prince Albert, which has been shown to be a good indicator of rootstock effect, on Worcester Pearmain and on October Pippin.

Representative rootstocks from five main vigour groups were included. They were :

Group 1.	Very vigorous	3430, M.XII, M.XVI.
Group 2.	Vigorous	M.II, M.I.
Group 3.	Intermediate	M.IV, M.VII.
Group 4.	Dwarf	M.IX, M.VIII, 3424.
Group 5.	Very dwarf	3413, 3431, 3426.

The vigour grouping of the Malling (M.) series of rootstocks is based on the results of 30 years' trials at East Malling Research Station. The grouping of the 34.. series is based on a preliminary trial at the Station. The root structure of these stocks has been described by Beakbane and Thompson (1947).

Measurements were made on one- to four-year-old stems which in most cases formed the main axes of branches. In one set of trees the bark percentage was also measured on the main stem.

Methods.

Hill and Beakbane (1947), and Beakbane and Thompson (1947) have shown that in roots the proportion of bark to wood decreases with increasing diameter. A similar relationship between the bark-wood ratio and the diameter is found also in stems. It is, therefore, important to compare only stems of similar diameter, or to apply a correction when stems of different diameters have to be compared.

The investigation was carried out over a period of three years. In 1949 the bark-wood ratio was determined in material of given diameter (method A). This involves a certain amount of selection of the material to be examined. There is also a danger that vigorously growing, thick shoots will be measured near the apex, while weak, thin shoots are measured close to the base. To avoid this the basal and distal quarters of all shoots were discarded, and all measurements were made in the middle half of the shoot. The results were examined by an analysis of variance.

The relationship between the increase in diameter and decrease in the bark-wood ratio was investigated in stems of Cox's Orange Pippin and Bramley's Seedling. Each variety had a characteristic regression slope, which was unaffected by the rootstock. In 1950 and 1951, therefore, all measurements on these two varieties were made in the middle of each year's growth, irrespective of diameter (method B). It was found that, measured in this way, the variation between trees of the same treatment was generally lower than when stems were measured at a given diameter.

* In this paper the term ' stem ' is used in its general sense of the ascending portion of the plant. Stem therefore includes one-year-old shoots, branches, and the main stem or trunk, as specified in each case.

In all cases the proportion of bark to wood is expressed as the percentage of the total cross-sectional area occupied by the bark, or 'bark percentage'. It was calculated from calliper measurements of the diameter before and after removing a ring of bark. All measurements were made in the middle of an internode, where irregularities of the wood-cylinder, due to emergence of bud and leaf traces, are least.

Determinations of the bark-wood ratio in stems by means of calliper measurements suffer from the disadvantage that the area occupied by the pith, a primary tissue not wood, is automatically included in the area of the wood-cylinder. The pith area varies in different shoots, and in very thin shoots it may constitute a large proportion of the wood-cylinder. In spite of this difficulty, a rootstock effect on the bark percentage of one-year-old shoots was demonstrated. In stems of larger diameter the area occupied by the pith is relatively insignificant.

Results.

All results were examined statistically ; by an analysis of variance for stems of similar diameter (method A), and by an analysis of covariance for stems measured at different diameters (method B). The data were examined in transformation and consequently no significant differences can be quoted. Instead brackets are used to indicate absence of significant differences ($P = 0{\cdot}05$) within the group enclosed.

The investigation suggested that the rootstock effect on the bark percentage of the scion stem is related to the state of development of the tree, which is determined by the rootstock, the age of the tree, the method of pruning and other environmental conditions. One thousand eight hundred and fifty measurements were made, and only typical examples are described here. The results have been grouped according to the age of the trees examined. A more detailed description of the trees is given with each set of results.

Maidens (one-year-old trees).

Two sets of maiden trees were measured. In neither was there an appreciable difference in the height of trees on different rootstocks. The first set of trees, measured in 1949, consisted of the variety October Pippin* on five clonal Malling rootstocks ranging from M.II (vigorous) to M.IX (dwarf). The one-year-old main stems were measured from five trees of each combination at a fixed diameter (method A). The results are given below. There was no significant difference in the bark percentage of maiden trees, and this result was confirmed in 1951 on maiden trees of Bramley's Seedling. The results of measurements made in the middle of the annual growth (method B) are given below.

	Vigour group :	1	2	2	3	3	4
Variety.	Mean bark percentage of five stems. on :	M.XVI	M.II	M.I	M.VII	M.IV	M.IX
October Pippin.	at 0·9-1·0 cm. diam.		32·0	34·5	32·7	30·5	33·3
Bramley's Seedling.	at corrected diam. of 0·95 cm.	40·6					42·6

Three- and four-year-old orchard trees.

This set of trees had been pruned very lightly (regulated), and trees were cropping heavily on the dwarf and very dwarf rootstocks. On the very vigorous stocks they were only just beginning to crop in their fourth year. Measurements of bark percentage were made on wood removed during pruning in the spring of 1949, and they were repeated on similar material in the following year.

		Vigour group :	1	1	4	4	5
Mean bark percentage of five stems of Cox's Orange Pippin.		on :	3430	M.XVI	M.IX	3424	3426
Measured in 1949 on one-year-old shoots	at 0·48-0·62 cm. diam. (method A).		42·1	43·3	53·8	56·7	50·6
Measured in 1950 on two-year-old stems	at corrected diam. of 0·67 cm. (method B).		38·0	40·6	47·5	44·5	45·7

In both years the bark percentage of stems on the very vigorous rootstocks 3430 and M.XVI was significantly lower than on the dwarf and very dwarf stocks M.IX, 3424 and 3426. Differences in bark percentage of stems on the dwarfing and very dwarfing rootstocks were not significant, and they were not consistent in the two years, possibly owing to the fact that prunings from dwarf trees were not truly representative material. On a different set of trees, where representative branches could

* A seedling not yet introduced to commerce.

be removed, a better correlation was obtained between bark percentage of stems and rootstock vigour in the dwarf and very dwarf vigour groups. This will be described next.

Eight-year-old trees.

These trees, of variety Cox's Orange Pippin on the rootstocks shown below, had been grown as a modified form of dwarf pyramid, but had received no summer pruning. The trees were in full cropping on the dwarf and very dwarf stocks, but on the very vigorous stock M.XII they had not yet borne a crop, and on the rootstock 3430 they were only just beginning to do so.

Measurements were made in the middle of one-, two-, three- and four-year-old stems (method B). The trees had been winter pruned in the usual way, and only a portion of the two-, three- and four-year-old wood was left, but it is considered that the material available was fully representative.

Bark percentages measured in the spring of 1950, based on the means of three to five observations, each made on a different tree, were as follows :

Vigour group :	1	1	2	3	4	5	4	5	5
One-year-old stems on :	3430	M.XII	M.II	M.VII	M.IX	3413*	3424	3431	3426*
at corrected diam. of 0·45 cm.	46·6	49·2	49·3	51·5	53·8	53·9	54·9	55·1	59·1

Vigour group :	1	1	3	2	4	4	5	5	5
Two-year-old stems on :	M.XII	3430	M.VII	M.II	3424	M.IX	3413	3431	3426
at corrected diam. of 0·65 cm.	37·9	39·7	41·8	46·5	48·6	48·6	49·1	53·2	53·4

Vigour group :	1	1	3	2	5	4	4	5	5
Three-year-old stems on :	M.XII	3430	M.VII	M.II	3426	3424	M.IX	3413	3431
at corrected diam. of 0·8 cm.	36·6	37·2	39·8	42·9	43·9	45·6	45·8	48·8	49·6

Vigour group :	1	1	2	3	4	5	5
Four-year-old stems on :	3430	M.XII	M.II	M.VII	3424	3431	3426
at corrected diam. of 1·0 cm.	32·7	33·0	38·6	40·5	44·3	49·1	50·8

* 3413 and 3426 differ significantly.

In Fig. 1 the measurements obtained from this set of trees are presented in a different manner. The original figures, not corrected for differences in diameter, have been averaged for each year's growth for each treatment. Each point on the graph represents the mean of three measurements. The graphs show clearly both the rootstock effect on stem bark percentage, and its relation to stem diameter.

There is a striking degree of similarity between these curves and those obtained by Beakbane and Thompson (1947) for the root bark percentage of the rootstocks themselves.

On the rootstock M.VII the stem bark percentage curve follows a rather different pattern from those on the other stocks. It has been observed that trees on M.VII rootstock grow vigorously at first, but after some years many fruit buds are produced, and the trees finally remain in the intermediate vigour group. The curve indicates that the bark percentage of individual branches may undergo a similar development. At two years old the bark percentage is very similar to that on very vigorous stocks, but in the third and fourth years it rises, and in the fifth year it is intermediate between that on the vigorous rootstock M.II and the dwarf M.IX.

Six-year-old unpruned trees, grown in nursery rows.

In these trees rootstock influence could be studied without any complications due to earlier pruning. Three varieties, Cox's Orange Pippin, Worcester Pearmain and Bramley's Seedling, were included on the two rootstocks M.XVI (very vigorous) and M.IX (dwarf). All three varieties were fruiting on M.IX, but they were only beginning to bear a small crop on M.XVI. In addition the stem-bark percentage of the two unworked rootstocks, M.IX and M.XVI, was also measured.

All measurements were made in the spring of 1949 at a fixed stem diameter (method A).

Variety :	Age of Stem :	Vigour group : 1 Mean bark percentage of five stems on : M.XVI	4 M.IX
Cox's Orange Pippin.	1 year. diam. 0·35-0·45 cm.	41·8	54·5
	2 year. diam. 0·54-0·65 cm.	36·4	45·4
Worcester Pearmain.	1 year. diam. 0·43-0·49 cm.	43·1	54·4
	2 year. diam. 0·57-0·68 cm.	35·7	47·2
Bramley's Seedling.	1 year. diam. 0·54-0·60 cm.	40·8	50·1
	2 year. diam. 0·68-0·81 cm.	34·5	47·7
Unworked rootstocks.	1 year. diam. 0·46-0·54 cm.	40·8	47·8
	2 year. diam. 0·64-0·78 cm.	33·2	41·9

On this set of trees some measurements were also made on the main trunks of trees at a diameter of 2·5 cm. There were significant differences of approximately 5 per cent between the bark percentage of trunks of Cox's Orange Pippin and Bramley's Seedling on M.IX and on M.XVI. The values for trunks of the unworked rootstocks differed by 10 per cent.

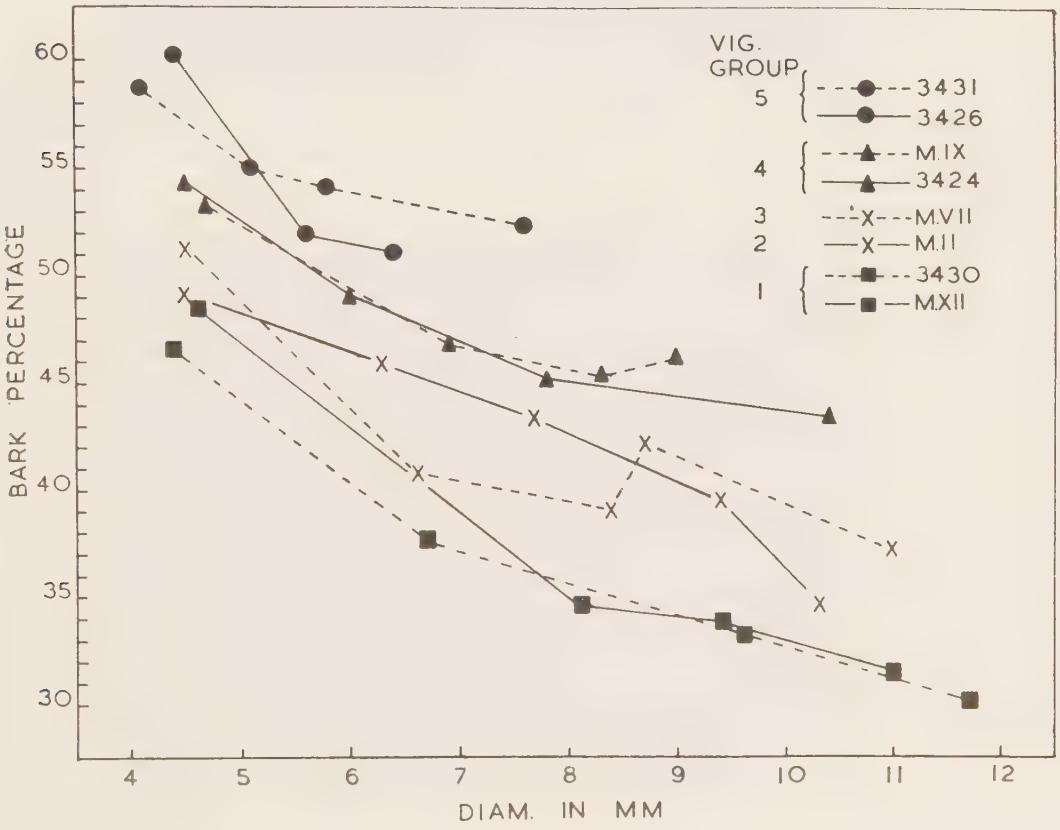


Fig. 1.

Bark percentage of stems of Cox's Orange Pippin on a range of rootstocks.

Fully mature orchard trees.

It remained to investigate the bark-wood relationship of scion stems in mature trees which were bearing a full crop on both dwarf and vigorous stocks. Four sets of trees were available, and two typical examples are described below.

In the spring of 1949 measurements were made on one- and two-year-old stems of the variety Lane's Prince Albert from twenty-five-year-old trees pruned by a spur pruning and leader tipping method. Trees on four rootstocks from two different vigour groups were selected, M.XII and M.XVI

(very vigorous), and M.VIII and M.IX (dwarf). The bark percentage of one- and two-year-old stems measured at a fixed diameter (method A) was as follows :

		Vigour group :	1	1	4	4
Lane's Prince Albert on :			M.XVI	M.XII	M.VIII	M.IX
Mean bark percentage of five stems.	one-year-old, diam.	0·47-0·55 cm.	43·0	44·3	45·5	46·2
	two-year-old, diam.	0·69-0·88 cm.	36·3	36·6	43·0	42·9

The bark percentage of one-year-old stems on dwarf and very vigorous stocks did not differ significantly, and in two-year-old stems it differed only by 6 per cent. A similar trend was shown by measurements made in the spring of 1950 on some sixteen-year-old trees of Cox's Orange Pippin on the rootstocks M.XVI and M.IX. The trees had been pruned by the renewal method, and they were bearing full crops on both stocks. One-, two- and three-year-old stems were measured, using method B.

		Vigour group :	1	4
Cox's Orange Pippin on :			M.XVI	M.IX
Mean bark percentage on eight stems.	one-year-old, diam.	0·44-0·46 cm.	54·2	57·5
	two-year-old, diam.	0·65-0·70 cm.	45·1	49·9
	three-year-old, diam.	0·80-0·84 cm.	39·7	45·8

As with the variety Lane's Prince Albert it was only in the older stems that the bark percentage of Cox's Orange Pippin on M.XVI was significantly smaller than on M.IX, the difference being of the order of 6 per cent. In younger trees, which were showing clear differences in the relative amount of crop, the bark percentage of one- and two-year-old stems of Cox's Orange Pippin on M.IX and M.XVI had differed by as much as 12 per cent. A similar result was obtained for the variety Bramley's Seedling where the bark percentage of stems on young trees on M.IX and M.XVI had differed by 13 per cent, whereas in older trees in full cropping it differed by only 7 per cent.

It seems that two factors may be suggested as contributing to the difference in bark percentage of young trees on vigorous and dwarfing stocks, a rootstock effect which persists in mature trees, and an additional effect in young trees which may be associated with their early cropping on the dwarfing rootstocks. To test this shoots from mature trees of unworked rootstocks were compared with vigorously growing shoots arising from the base of similar trees which had been cut down to ground level in the previous year. Shoots from the rootstocks M.XVI, M.II, M.I, M.IX and the very dwarf rootstock 70 were measured ; in each case the bark percentage was higher in shoots from the fruiting trees.

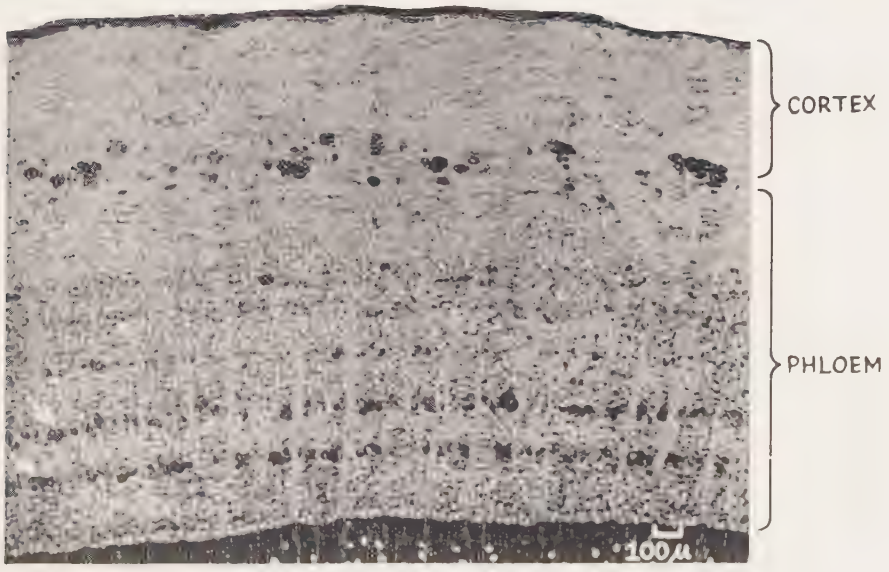
Observations on bark structure.

The larger bark percentage of stems on dwarfing rootstocks could be due to an increase in either the cortex or the secondary phloem. Measurements were made of the radial width of both tissues in transverse sections of the main stem of eight-year-old trees of Cox's Orange Pippin and Bramley's Seedling on M.XVI and M.IX rootstocks and of stems of the unworked rootstocks M.XVI and M.IX. The results, expressed in units of 10 μ, are given below. Each figure represents the mean of three measurements on each of three sections, taken from the main stem of a separate tree at a point where the diameter was 2·5 cm. Figures not bracketed together differed significantly at the 5 per cent level.

	Cox's Orange Pippin on :		Bramley's Seedling on :		Unworked rootstocks :	
Vigour group :	1	4	1	4	1	4
	M.XVI	M.IX	M.XVI	M.IX	M.XVI	M.IX
Cortex	38	48	53	70	32	30
Phloem	115	147	101	120	80	166
Total Bark	153	195	154	190	112	196

In both Cox's Orange Pippin and Bramley's Seedling the larger proportion of bark on M.IX rootstock was due to an increase in both phloem and cortex. This is illustrated in Fig. 2, which shows photomicrographs of the bark of Bramley stems on M.XVI and M.IX respectively. The strong development of the phloem fibres on the more vigorous rootstock appeared to be characteristic of all the stems of this stock.

on M.XVI



on M.IX

Fig. 2

Transverse section of the bark of Bramley's Seedling stems on two rootstocks, M.XVI and M.IX. The phloem fibres are indicated by arrows.

Discussion.

It has been shown that the bark percentage in stems of several apple varieties is larger on the dwarfing rootstocks than in comparable trees of the same variety growing on more vigorous stocks. This result, based on measurements of the relative area of wood and bark, is confirmed by the work of Rao and Berry (1940) on the basis of residual dry weights. The figures of residual dry weight given in Table X of their paper indicate that at each of the seven sampling dates between July and October the bark-wood ratio was higher in stems on the dwarf rootstock M.IX than on the vigorous M.XIII. The difference was most pronounced during September and October.

The work of Beakbane and others suggests that the dwarfing effect of a rootstock may be associated with the large proportion of living cells in its tissues. It is now shown that the larger amount of living cells is not confined only to the roots, but that it extends also to the scion stem on dwarf rootstocks.

The rootstock effect on the bark percentage of stems did not occur equally in trees of all ages, but appeared to be influenced by the state of development of the tree and the balance it had reached between vegetative growth and cropping. In the one-year-old budded trees described in this paper there was no significant difference in the bark percentage of scion stems on dwarf and vigorous stocks, but there was also no appreciable rootstock effect on the maiden growth. On the other hand Colby and also Rao and Berry, working with one-year-old grafted trees, recorded a small difference in maiden growth which was associated with differences in the bark-wood ratio of the scion stems. Differences in bark percentage were found to be most pronounced where trees on the vigorous rootstocks were still mainly vegetative, while comparable trees of the same variety on the dwarfing stocks were already in full bearing. In mature trees which were bearing a full crop on both types of stock differences were of the order of 6 per cent. This represented an increase of approximately 25 per cent in the radial width of the bark of scion stems on dwarfing rootstocks. A possible interpretation of these results is that the bark percentage is influenced by at least two factors, a rootstock effect which persists throughout the life of the tree and an increase in the proportion of bark which occurs, in both grafted and unworked trees, when the trees come into cropping.

Summary.

1. The bark percentage of stems of several apple varieties on a range of rootstocks was determined by calliper measurements.

2. It was found that scion stems on dwarfing rootstocks had a greater bark percentage than stems of the same scion variety on vigorous rootstocks.

3. Differences in bark percentage did not occur equally on trees of all ages, but were greatest where trees on the dwarf rootstocks were already cropping fully, while comparable trees on vigorous stocks were still mainly vegetative.

4. It is suggested that there is a direct rootstock effect on the bark percentage, which persists throughout the life of a tree, and that there is also an increase in the bark percentage of both grafted and unworked trees, when a tree enters the fruiting phase.

Acknowledgements.

The help of Dr. A. B. Beakbane throughout this investigation is acknowledged with grateful thanks. Thanks are also due to Mr. J. Taylor for the statistical analyses, to Miss E. C. Thompson for the photographs, and to Mr. A. P. Preston for some of the material.

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ANATOMICAL STUDIES OF STEMS AND ROOTS OF HARDY FRUIT TREES

V. THE HISTOLOGY OF THE ROOTS OF THE APPLE MALLING CRAB C WHEN BUDDED WITH CERTAIN SCION AND ROOTSTOCK VARIETIES

By ELEANOR C. THOMPSON

Introduction.

In view of the close relationship already shown to exist between rootstock root structure and scion behaviour (Beakbane and Thompson, 1939, 1947) the extent of any possible scion influence on the root structure is of interest. This study was undertaken to find out whether the scion had any influence on the structure of the roots of the rootstock on which it was budded, and, if so, whether the effect was correlated with the stem structure of the scion itself.

Scion influence on the histological structure of seedling rootstock roots after grafting was reported by Swarbrick and Roberts (1927), who stated that the new xylem produced in seedling roots after bench grafting was uniform and typical of the scion variety.

The vessels of M.IX apple rootstock roots are characteristically very small, but Colby (1935), working with high and low nitrogen varieties grafted on M.IX and M.XII apple rootstocks stated that " the most outstanding anatomical feature of the ' dwarfing ' roots as altered to support vigorous top growth of the Snow scion was the enormous development of large open vessels in the xylem of the Malling Nine young roots ". Beakbane and Renwick (1936) also showed that the vessels in M.IX roots varied in size when this rootstock was grafted with a number of different scion varieties, but no relation was found between the size of vessels in the rootstock roots and in the scion roots of those varieties which had become scion-rooted ; the authors concluded that scions with large vessels in their own roots did not necessarily induce an increase in the size of vessels in the M.IX roots on which they were grafted.

Herrero (1951) found no scion influence after one year on the composition of the wood of roots of Myrobalan B and Quince B rootstocks when grafted with certain scion varieties.

Material and methods.

The material available consisted of the clonal rootstock Malling Crab C (Garner, 1946), budded with the following scions ; rootstocks M.IX, M.XII, M.XIII, 3426 and Ivory's Double Vigour, and the apple varieties Bulmer's Norman, Lane's Prince Albert and Heusgen's Golden Reinette. As a control Crab C was budded on itself.

The one-year layers of Crab C were budded with the nine scion varieties at 4 inches above ground level in 1944, the varieties being arranged at random. They received routine nursery treatments, but no pruning. The trees were lifted in April, 1948, after three growing seasons and growth records were made on each of three trees of each combination.

The data show that, when worked on Crab C, the relative performance of the scion varieties was very different from what experience of these varieties as scions or as rootstocks would suggest. Thus, while the growth of Crab C and M.XIII on Crab C was vigorous, that of Heusgen's Golden Reinette was the weakest. An intermediate group may be regarded, if the groupings suggested by statistical analysis are considered, as consisting of the relatively vigorous variety Bulmer's Norman, and surprisingly, M.IX, with Ivory's Double Vigour, Lane's Prince Albert and M.XII on the whole giving less vigorous growth. The position of 3426 is anomalous ; it may perhaps be regarded as also belonging to the intermediate group. It will be noticed that the two scions which have proved dwarfing when used as rootstocks in former trials (Tydeman, 1933, 1943) M.IX and 3426, have made more shoot growth than some of the vigorous scions ; that of 3426 is mostly in the form of long thin shoots originating from the base of the tree, as can be seen in Fig. 1. The extra growth of these two scions is reflected also in the weight of head.

Permanent, transverse sections were made of the stem and two roots of each of three trees of each combination of scion and rootstock. The sections of the stems were taken at a diameter of 7-9 mm. and stained with Safranine and Light Green, those of the roots 7-10 mm. and stained with Safranine and Fast Green. Photomicrographs with a magnification of 475 diameters were taken of four fields, located at each end of two axes at right angles to one another in the middle of the 1947

Fig. 1.

Three-year-old trees of the nine scion varieties, each worked on Malling Crab C :

M.XIII. Ivory's Double Vigour | Crab C | M.XII. Bulmer's Norman | M.IX. Heusgen's Golden Reinette. | 3426. | Lane's Prince Albert.

[face p. 76

annual xylem growth ring for each of two stems of each combination, and at a distance of 0·6 mm. in from the cambium for all roots. The percentage areas occupied by fibres, vessels, parenchyma cells, and rays in the wood of stem and root were estimated by weighing the corresponding parts cut from these photomicrographs. The number of fibres, vessels, and parenchyma cells on each photomicrograph was counted, and the mean size of each in stems and roots calculated from the determinations of number and area.

The bark percentage of each root was determined from calliper measurements of preserved pieces of the same roots which were used for the sections. The bark percentage of the stems of all three

TABLE I.

MEAN PERFORMANCE OF NINE SCION VARIETIES ON CRAB C AT THREE-YEARS-OLD.

Scion.	Weight of Head. Hectogm.	Scion.	Height. cm.	Scion.	Girth. cm.	Scion.	Total shoot growth. cm.	Number of fruit buds.
Crab C	12·9	Crab C	296	M.XIII	10·4	3426	2,460	1
M.XIII	12·1	M.XIII	256	Crab C	9·5	Crab C	1,910	0
Bulmer's Norman	8·0	Ivory's Double Vigour	220	M.IX	8·0	M.XIII	1,758	3
M.IX	7·8	Lane's Prince Albert	211	Lane's Prince Albert	7·6	M.IX	1,517	25
3426	6·5	Bulmer's Norman	209	Ivory's Double Vigour	7·5	Bulmer's Norman	1,371	1
Ivory's Double Vigour	6·0	M.XII	200	Bulmer's Norman	7·5	M.XII	787	0
Lane's Prince Albert	5·4	M.IX	190	M.XII	6·9	Lane's Prince Albert	731	98
M.XII	5·1	Heusgen's Golden Reinette	153	Heusgen's Golden Reinette	5·6	Ivory's Double Vigour	644	7
Heusgen's Golden Reinette	2·6	3426	140	3426	5·1	Heusgen's Golden Reinette	356	8

trees of each combination was determined from measurements made on the permanent sections with an eyepiece micrometer.

The total amount of living tissue in stems and roots was determined in each case from the bark percentage together with the percentage of living tissue in the xylem.

Bark percentage.

The bark percentage of the scion stems and of the Crab C roots under the scions is shown in Table II. The figures bracketed together do not differ significantly ($P = 0·05$).

TABLE II.

MEAN BARK PERCENTAGE OF THE STEM AND ROOT IN EACH COMBINATION OF NINE SCION VARIETIES WITH CRAB C ROOTSTOCK.

Scion variety.	Bark percentage.	
	Scion stem.	Crab C root.
Bulmer's Norman	33·1	37·8
Ivory's Double Vigour	39·1	40·0
Crab C	36·0	41·6
Heusgen's Golden Reinette	30·8	42·1
M.XII	33·7	42·4
M.XIII	35·7	43·0
Lane's Prince Albert	36·2	43·5
M.IX	33·5	45·2
3426	40·4	48·4
Significant difference (P=0·05)	*Not significant*	*3·86*

With the exception of the root below the very dwarf 3426 scion there appears to be no great variation in the bark percentage of the Crab C roots. Under 3426 the roots of the Crab C have significantly more bark than when under any other scion except M.IX. Although there were significant differences in the bark percentages of the Crab C roots there was no correlation between the bark percentage of a root and that of the stem of the scion budded on it, a not unexpected result in view of the variability in the bark percentage within scion varieties.

Relative areas of fibres, vessels, parenchyma cells, and rays.

Table III shows the mean percentage areas of fibres, vessels, parenchyma cells, and rays, in transverse sections of the wood of the stem and root of two trees of each combination of scion and rootstock. Figures marked with an asterisk differ significantly ($P=0·05$) from all other values in the column. The composition of the wood of the stems of the scions M.IX and 3426 differs markedly from that of the other scions in having a significantly larger amount of parenchyma cells and ray

TABLE III.

MEAN PERCENTAGE AREA OF FIBRES, VESSELS, PARENCHYMA CELLS, AND RAYS, IN THE WOOD OF STEM AND ROOT IN EACH COMBINATION OF NINE SCION VARIETIES WITH CRAB C ROOTSTOCK.

Scion variety.	Scion stems.				Crab C roots.			
	Fibres.	Vessels.	Parenchyma cells.	Rays.	Fibres.	Vessels.	Parenchyma cells.	Rays.
M.XIII	44	38	2	16	37	13	35	16
Bulmer's Norman	49	29	3	18	40	11	31	18
Crab C	45	34	4	18	35	14	32	18
Ivory's Double Vigour	53	24	4	19	39	12	29	20
Lane's Prince Albert	51	24	4	20	39	17	25	18
Heusgen's Golden Reinette	48	29	4	20	44	10	28	18
M.XII	45	31	5	20	39	12	30	19
M.IX	40	27	7*	26*	33	12	35	20
3426	40	14*	11*	34*	29	17	37	17
Significant difference (P=0·05)	*6·3*	*5·3*	*1·3*	*5·4*	*6·8*	*Not significant*	*3·6*	*Not significant*

tissue. 3426 also has a significantly smaller amount of vessel elements than any other scion, and it is the only variety possessing a smaller area of vessels in the stem than in the root of the Crab C under it.

Significant differences were found in the Crab C roots for the areas of fibres and parenchyma cells under the different scions but not in the areas of vessels or of rays. Separate analyses were carried out to test whether the variation in the percentage areas of fibres, vessels, parenchyma cells, and rays, in the Crab C roots within and between scions was related to the variation in the corresponding elements in the scions budded on those roots. In no case was any correlation found.

Size of fibres, vessels, and parenchyma cells.

The mean size in sq. μ of fibres, vessels, and parenchyma cells, in transverse sections of the wood in the scion stems and in the Crab C roots beneath them from two trees of each combination is given in Table IV. Figures marked with an asterisk differ significantly from all others in the column.

TABLE IV.

MEAN SIZE OF CELLS IN THE WOOD OF STEM AND ROOT OF NINE SCION VARIETIES ON CRAB C ROOTSTOCK, IN SQUARE μ.

Scion variety.	Fibres.		Vessels.		Parenchyma.	
	Scion stem.	Crab C root.	Scion stem.	Crab C root.	Scion stem.	Crab C root.
Crab C	112	145	857	1,665	135	326
M.XIII	102	152	759	1,882	126	333
Ivory's Double Vigour	84	138	649	1,737	100	297
Lane's Prince Albert	153*	152	673	2,099	121	275
Bulmer's Norman	126	152	1,298*	1,520	164	275
M.XII	109	152	1,016	1,737	133	304
M.IX	114	159	882	1,954	170	318
Heusgen's Golden Reinette	93	145	796	1,447	131	275
3426	135	152	465*	2,316	206*	340
Significant difference ($P=0\cdot05$) ..	*16·9*	*Not significant*	*175·6*	*Not significant*	*32·1*	*Not significant*

Separate analyses for the size of fibres, vessels, and parenchyma cells, in the Crab C roots, with a covariance correction for the size of these cells in the scion stems, showed that there were in each case no significant differences between the effects of scions on the Crab C roots whether or not the correction was made. There was no correlation between the sizes of the different cells in the root and stem of each combination.

It is to be noted that the stem of Lane's Prince Albert has larger fibres than any of the other scion varieties ; that the stem of Bulmer's Norman has larger, and that of 3426 smaller, vessels than any of the other scion varieties ; and that the stem of 3426 also has larger parenchyma cells than any of the other scions. Not one of these stem characteristics, however, is associated with any significant change in the corresponding elements in the structure of the Crab C root below it, though it is noticeable that the Crab C root with the largest parenchyma cells is that which is below the 3426 scion. It is interesting to note also that the Crab C roots with the largest vessels are those which are associated with the scion variety having significantly smaller vessels than any of the other scions.

Living tissue in stems and roots.

The mean percentage of living tissue in the wood, and of total living tissue, for the scion stems and for the roots of the Crab C rootstock beneath each of them from the two trees of each combination is given in Table V.

The stems of M.IX and 3426 both have a higher amount of living tissue in the wood than any of the other scion varieties. This is reflected in a small way in the structure of the Crab C roots beneath them, for the amount of living tissue in the wood of the Crab C root below M.IX is significantly higher than that in any other root except that below the scion 3426. The amount of living tissue in the wood of the root of the Crab C below 3426 was significantly higher than that of the Crab C roots below all the scion varieties except M.IX and Crab C.

There were significant differences in the amount of total living tissue in the scion stems ($P = 0\cdot001$), and in the Crab C roots ($P = 0\cdot01$). The scion 3426 possessed a higher amount of total living

TABLE V.

MEAN PERCENTAGE OF LIVING TISSUE IN THE STEM AND ROOT OF EACH COMBINATION OF NINE SCION VARIETIES WITH CRAB C ROOTSTOCK.

Scion variety.	Percentage of living tissue in wood of		Percentage of total living tissue in	
	Scion stems.	Crab C roots.	Scion stems.	Crab C roots.
Lane's Prince Albert	24·4	43·2	51·1	67·0
Heusgen's Golden Reinette	23·8	46·2	47·4	68·5
Bulmer's Norman	21·3	48·6	43·2	68·8
Ivory's Double Vigour	23·0	49·2	52·5	69·6
M.XII	24·5	49·0	49·3	70·7
Crab C	21·2	50·2	51·0	71·5
M.XIII	18·1	50·1	45·0	71·6
M.IX	32·8*	55·0	54·3	76·0
3426	45·5*	54·3	66·8*	76·7
Significant difference (P=0·05)	*5·03*	*4·18*	*4·54*	*4·32*

tissue than any other scion variety. This was reflected in the amount of total living tissue in the Crab C roots; the roots below 3426 contained an amount of total living tissue which was significantly higher than that of the roots below all the scions except M.IX. The roots below M.IX also contained a significantly higher amount of total living tissue than roots below the other seven scions. Correlation between the total amounts of living tissue in stem and root was found to be just significant ($P = 0·05$), the value being 0·702.

Conclusion and discussion.

Histological examination of trees of nine scion varieties, differing in their stem structure, each budded on the vigorous rootstock Crab C, showed no correlation between stem and root structure for a number of features, but there was some indication that, after three year's growth, the greater the amount of total living tissue in a scion stem, the greater the amount of total living tissue in the root of the rootstock on which it was budded.

The increase in living tissue in the root comprised an increase in the amount of bark (Table II) and xylem parenchyma cells (Table III); it was greater than might be expected in the normal variation in structure for a root of 7-10 mm. diameter, and was more marked under M.IX and 3426, in which the stems were relatively high in xylem parenchyma cells and rays (Table III) and in total living tissue (Table V).

The difference found between the stem values for M.IX and 3426 and the mean value for all the other scion varieties in respect of the amount of total living tissue was about 12 per cent and 38 per cent, respectively, and the increase in the total living tissue in the Crab C rootstock roots under these dwarfing scions was of the order of 10 per cent. For roots in the same size range there is a similar percentage difference between the amounts of total living tissue in the vigorous rootstocks M.XII, the root structure of which closely resembles that of Crab C, and M.I, the difference here also consisting of an increase in amount of bark and xylem parenchyma cells (Beakbane and Thompson, 1947).

A drastic change in the environment of a plant tissue may cause a large change in its structure. A difference of about 18 per cent was found between the amounts of total living tissue in M.XII roots grown above and below ground level (Beakbane, unpublished data). In general, however, under normal growing conditions, the structure of the clonal rootstocks has been found to be sufficiently constant for it to be used as a reliable diagnostic feature.

Although there were differences in tree size, and some trees had reached the reproductive phase, neither of these factors alone could have been responsible for the changes in root structure, for Table I shows that the tree size of Bulmer's Norman was similar to that of M.IX, and that Lane's Prince Albert, Heusgen's Golden Reinette, and Ivory's Double Vigour had also reached the fruiting phase; yet there was less total living tissue in the roots of the Crab C rootstocks on which each of these four varieties was budded than in the rootstock roots under any of the other scions.

It is noteworthy that the behaviour of the M.IX and 3426 scions on Crab C rootstock is not altogether in accord with what might be expected from their marked 'dwarfing' effects when used as rootstocks or from their anatomical structure.

Summary.

1. The anatomy of the roots of Crab C rootstock was examined in three-year-old trees budded with four apple varieties, four rootstocks, and Crab C itself as control. The root structure was compared with the scion stem structure within each combination of rootstock and scion.

2. The scions varied greatly in growth and fruit bud formation and in the structure of their stems.

3. Histological examination showed no correlation between the structure of scion stem and rootstock root for the relative size and amount of xylem fibres, vessels, and parenchyma cells ; the amount of xylem ray tissue ; and the bark percentage ; but there was some slight indication that the greater the amount of total living tissue in the stem of the scion variety the greater the amount of total living tissue in the root of the Crab C rootstock on which it was budded.

Acknowledgements.

The author wishes to thank Dr. A. B. Beakbane for valuable criticism and advice in connexion with the presentation of this paper. She is also indebted to Dr. S. C. Pearce and Mr. J. Taylor for analysing the data, and to Mr. R. J. Garner for the material and for permission to use the photograph.

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RASPBERRY VARIETIES IN GREAT BRITAIN

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Introduction.

Since the publication in 1922 of N. H. Grubb's paper "Commercial Raspberries and their Classification", wide changes have occurred in the range of raspberry varieties available for planting in Great Britain. Not one of the twenty then described in detail is commercially important to-day. A few, such as Pyne's Royal, Red Cross and Devon, are occasionally found in commerce, and several in gardens, but these are steadily disappearing. In contrast, one of the then recent introductions noted by Grubb, namely Lloyd George, was destined soon to become a staple variety, displacing many older sorts from both commercial and garden cultivation.

Recent research has established beyond doubt the decisive effect of virus diseases in causing the elimination of many once popular raspberry varieties, and has shown that only by rigorous care can those of to-day be safeguarded (Harris and Cadman, 1949). It is also true that purely horticultural characters have been important, and frequently decisive, in determining the future of a particular variety. Thus Lloyd George owed its rise mainly to an inherent superiority in cropping capacity and fruit size over contemporary varieties. Its subsequent decline, however, was the result of widespread virus infection, and its recent resuscitation became possible only through the use of stocks which had remained healthy in New Zealand.

The present expansion in raspberry growing has brought increased popularity to the new varieties developed at East Malling Research Station. Several of these have sufficient cropping capacity for the commercial jam trade, and some are of suitable fruit quality for the fresh fruit market and newer forms of processing.

Characters desirable in modern raspberry varieties.

The characters sought in a commercial raspberry vary with the type of market served. Essential to the grower are an inherently good yielding capacity and the availability of reliable, healthy stock. Also desirable are a fairly erect habit of growth ; a tendency to form compact stools ; adequate but not excessive cane production ; smooth canes, without troublesome spines ; strongly attached fruiting laterals ; and fruit both conspicuous and easily separable from the husk or plug. A variety should not be seriously susceptible to spring frosts, fungus diseases or insect pests.

Modern developments in processing place increased emphasis on characters of fruit quality. Most raspberry varieties are acceptable for jam fruit, choice being exercised largely by the grower on the bases of yield, ease of picking and period of ripening. Yet varietal preferences do exist in the jam trade, Norfolk Giant and Newburgh usually being considered superior to Lloyd George, which in turn is preferred to Malling Promise. Of greater concern are the requirements of the canning and quick-freezing trades, where texture, size, colour and flavour assume high importance. Few varieties combine high cropping capacity with the qualitative standards demanded by these markets, but Malling Jewel, Lloyd George, Norfolk Giant and the Scottish variety Burnetholm Seedling are among the best available. Growers for such markets have primarily to choose varieties combining suitable processing characteristics with good fruit quality. Similarly, raspberries for the fresh fruit trade should be of good flavour, size and appearance, and, above all, firm enough in texture to allow them to be marketed in good condition. Development of improved general-purpose varieties, combining high yield with the highest fruit quality, clearly offers scope for further work by breeders.

Characters used in varietal identification.

Plant characters of value in the identification of raspberry varieties were discussed by Grubb (1922), whose account is here largely followed. He stressed the unstable nature of most identification characters and the difficulty of giving varietal descriptions which could guide others. In the following descriptions reference is made to the two least variable characters used by Grubb, namely the presence or absence of a hairy covering on the young growing canes in summer, and the colouring of their spines or prickles. It will be noted that young canes growing in spring and summer offer the surest means of varietal identification, although fruit and other characters are often useful.

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Fig. 1. Burnetholm Seedling.

Fig. 2. Lloyd George.

Fig. 3. Malling Enterprise.

Fig. 4. Malling Exploit.

Fig. 5. Malling Jewel.

Fig. 6. Malling Landmark.

FIG. 7. Newburgh.

FIG. 8. St. Walfried.

FIG. 9. Malling Notable.

FIG. 10. Malling Promise.

FIG. 11. Norfolk Giant.

First year canes are described as 'pubescent' or 'glabrous' according to the presence or virtual absence of a surface covering of minute hairs, distinguishable most readily near to the growing points. This is a constant varietal character : the surface of the youngest portion of a glabrous cane appears shiny, especially if gently rubbed, whereas that of a pubescent cane is always dull. Lower down the cane the distinction is usually less clear, because the bark of many glabrous varieties soon becomes 'glaucous' (covered with a waxy secretion). Only two of the varieties fully described here (Lloyd George and Burnetholm Seedling) have pubescent canes.

The spines on the middle and upper parts of a young cane are nearly always stout or broadened at the base, and where the latter is darkly pigmented in early summer it contrasts conspicuously with the green surface of the stem. Such spines are described as 'coloured', the pigmentation varying from red or purple almost to black. In other varieties the spine base has the same general colour as the stem, and is inconspicuous ; but in such cases the pointed portion is usually pigmented to a greater or less extent, sometimes only at the extreme tip. Spines of this kind are described as 'tinged'. Their bases usually become coloured in late summer or autumn at about the same time as the surface of the stem, and so remain inconspicuous. In raspberries with entirely colourless (or green) spines the fruit is always yellow or 'apricot' in colour. Little attention should be paid to spines on the lowermost portion of a cane, within a foot or so from the ground. There they are usually numerous, irrespective of variety, and often more slender and differently coloured than those produced later.

Other vegetative characters, although more qualitative and subject to the personal factor of the observer, are essential to the successful identification of most modern varieties. The habit of growth of first-year canes, the shade of green of young foliage and the shape and poise of leaves, can all be used in the growing season. Differences in the degree of grey, brown or purple coloration of canes during dormancy can be employed with caution. Fruit characters are generally useful and in a few cases highly distinctive, as in Malling Landmark and Malling Enterprise.

Descriptions.

The first eleven varieties here described in detail are believed to include all those now of commercial importance in Great Britain. Their characteristics are set out in Tables I and II. Other varieties, some recent but the majority passing from cultivation, are briefly described in a later section, together with certain 'hybrid' raspberries recently introduced for trial. The descriptions of varieties raised at East Malling Research Station are based on the original publications by N. H. Grubb, augmented by the writer's observations in Scotland.

Reports on the performance of most of the more important varieties and of several others have been published by Grubb (1943, 1946), Potter (1948), Wood (1950) and Wood and Boase (1952). More detailed notes on the health and virus disease reactions of modern varieties have been given by Cadman and Wood (1951).

Modern commercial varieties.

Burnetholm Seedling. Fig. 1. *Reference : Cadman and Wood* (1951).

A chance seedling selected by the late Alexander Weir, at Burnetholm, near Carluke, Lanarkshire, some 45 years ago.

This variety has hitherto been grown mainly in the Lanarkshire area of the Clyde Valley, where conditions seem specially to suit it. Although not outstanding in cropping, its good general dessert quality and particularly its firm texture make it very suitable for the Clydeside fresh fruit trade. Recent tests show it to be satisfactory for canning and probably also for quick-freezing.

Burnetholm Seedling is not eligible for inspection under present official certification schemes, and information on the health of commercial stocks is scanty. The majority in Clydeside appear to be vigorous, and at least one stock is known free from serious virus infection.

Lloyd George. Fig. 2. *References : Bunyard Cat.* 57 (1921); *Grubb* (1922, 1942); *Hedrick* (1925).

This raspberry is still widely grown throughout Britain, and in good health remains one of our heaviest cropping varieties. Yields of 4 tons per acre are not unusual. Although seriously susceptible to spring frost injury, it shows a marked capacity to recover by forming late-fruiting secondary laterals from buds immediately below the primary laterals. Normally among the earliest varieties to ripen, it has a fairly long picking season. The fruit, carefully picked, is suitable for canning, quick-freezing and the fresh fruit trade.

Older commercial stocks of Lloyd George are extensively infected with virus and lacking in vigour, and are gradually being replaced by the stock recently imported from New Zealand. This is free from serious virus infection and shows promise of high cropping capacity (Harris and Cadman, 1949 ; Wood, 1950). It is eligible for inspection under official certification schemes.

TABLE I.

VARIETY.	NEW CANES IN		
	Vigour.	Habit.	Pubescence and colouring.
Burnetholm Seedling.	Growth moderately vigorous. Canes usually abundant, rather slender.	Nearly erect below, arching above to become nearly horizontal.	Pubescent. At first green, soon becoming pink or reddish especially in unshaded parts.
Lloyd George.	Growth often very vigorous. Canes abundant, stout.	Semi-erect.	Pubescent. Mainly light green or greyish.
Malling Enterprise.	Canes tall, stout; generally few in number.	Nearly erect below, spreading above. Canes heavy, apt to suffer wind damage.	Glabrous. At first light or bluish green; markedly glaucous; later brown.
Malling Exploit.	Growth very vigorous. Canes abundant, sometimes very numerous; tall, fairly stout.	Somewhat spreading, though less so than Norfolk Giant. Canes often branched in young plantations.	Almost glabrous. Light green, becoming light brown.
Malling Jewel.	Growth vigorous. Canes fairly abundant, but sometimes insufficient.	Almost stiffly erect.	Glabrous. At first green, becoming red or purplish; a little glaucous.
Malling Promise.	Growth very vigorous. Canes very abundant, especially in young plantations.	Nearly erect.	Glabrous. Green for most of the growing season, gradually becoming light brown.
Malling Landmark.	Growth very vigorous. Canes fairly abundant, tall and stout.	Nearly erect, but not quite as erect as Malling Jewel or Newburgh.	Glabrous. At first light green, usually becoming reddish by late summer.
Malling Notable.	Growth moderately vigorous. Canes fairly abundant, but sometimes insufficient.	Nearly erect at base, spreading and sometimes slightly drooping above.	Glabrous. At first green, later becoming reddish-purple.
Newburgh.	Growth vigorous; canes abundant.	Stiffly erect.	Glabrous. At first green, usually becoming bright purplish-red by late summer.
Norfolk Giant.	Growth very vigorous; stool canes usually sufficient, often abundant; spawn canes often few.	Canes widely spreading, but with a pronounced 'stooling' tendency.	Glabrous. At first medium green, later often developing some reddish coloration.
St. Walfried.	Growth variable, but can show good vigour; canes usually abundant.	Semi-erect.	Glabrous. At first light green, becoming reddish-brown by late summer.

MODERN COMMERCIAL VARIETIES—VEGETATIVE CHARACTERS.

SUMMER.			
Spines.	Foliage.	DORMANT CANES IN WINTER.	VARIETY.
Coloured (purple or brown); small ; fairly numerous.	Medium green, dull ; young leaves pale green ; apical leaves yellowish, closely folded. Leaflets widely spaced, terminals mostly pointing downwards.	Dull medium brown.	**Burnetholm Seedling.**
Coloured (dark purple) ; short, stout; very numerous, conspicuous.	Medium green, bright; leaves flattish; leaflets broad, closely spaced.	Mainly greyish, with some brown coloration, chiefly in upper parts.	**Lloyd George.**
Coloured (very dark) ; conspicuous, but generally few and small except on weak or thin canes.	Medium or somewhat bluish green, rather dull ; leaflets large, broad, with margins often slightly down-curled.	Reddish-brown or purple.	**Malling Enterprise.**
Mainly tinged, but usually some dark coloured also ; fairly numerous but rarely troublesome.	Light or medium green, a little dull ; leaves fairly flat ; resembling Malling Promise, but leaflets narrower.	Light brown in lower parts, darker above.	**Malling Exploit.**
Tinged ; generally few ; always small and inconspicuous except on weak or thin canes.	Medium to dark green ; leaves markedly curled or rugose, especially in dry seasons or situations.	Medium to dark brown, with some purple colour in upper parts.	**Malling Jewel.**
Mainly coloured (brown or purple) ; sometimes tinged ; often numerous but rarely troublesome.	Mainly medium green, with slight reddish coloration in midribs, especially in young leaves.	Light or medium brown.	**Malling Promise.**
Tinged ; inconspicuous, but long and stiff ; variable in number ; often very troublesome.	Medium to dark green, heavy ; leaflets large, broad, generally slightly rugose, and tending to meet or overlap at the margins.	Deep reddish-brown.	**Malling Landmark.**
Coloured (dark) ; numerous, small.	Medium green, bright ; leaves near growing tips distinctly reddish, more so than in the similar variety Malling M.	Medium to dark brown above, greyish-brown below. Bud-scales conspicuously dark.	**Malling Notable.**
Coloured (purple or brown); numerous, fairly prominent, but seldom troublesome.	Mainly medium to dark green ; fairly glossy ; much coloured with reddish or purplish pigmentation ; leaflets narrow-pointed, tending to project stiffly upwards and outwards.	Deep reddish-brown above, lighter brown below.	**Newburgh.**
Coloured (dark purple or black) ; short, often few.	Light green, dull; petioles and midribs long and leaflets rather narrow, giving an ' open ' type of leaf.	Light to medium brown ; glossy.	**Norfolk Giant.**
Coloured (dark purple or black) ; small, generally few.	Light to medium green, a little heavy; terminal leaflets of older leaves usually point downwards ; leaflets large, often slightly overlapping ; margins slightly down-curled.	Light brown above, greyish below.	**St. Walfried.**

TABLE II.

VARIETY.	FRUITING LATERALS.	FRUIT.		
		Size.	Shape.	Texture.
Burnetholm Seedling.	Mainly short, strong and ascending.	Medium to large.	Roundish or oval ; smooth.	Firm, with small drupelets.
Lloyd George.	Medium to long; canes well furnished, often almost to ground level.	Very large.	Conical or somewhat oblong.	Firm.
Malling Enterprise.	Very stout ; mainly long and ascending.	Very large ; size well maintained through the season.	Roundish or slightly oval ; smooth.	Firm ; drupelets medium-sized.
Malling Exploit.	Often long ; sometimes apt to break ; tend to be drawn down into the foliage by the weight of fruit.	Very large; usually slightly larger than Malling Promise.	Oval-conical, fairly smooth.	Firm.
Malling Jewel.	Fairly short, sturdy.	Large, but tending to decrease during the season.	Conical.	Very firm.
Malling Promise.	Often long, but not seriously apt to break.	Very large.	Bluntly conical.	Firm at ripeness, soon softening.
Malling Landmark.	Long, very stout ; not readily breaking.	Large or very large ; size well maintained through the season.	Almost round.	Soft, juicy ; often damaged in picking.
Malling Notable.	Mainly short, stiff and ascending, except near ground ; not apt to break.	Mainly medium to large.	Short-conical.	Usually firm.
Newburgh.	Strong ; of medium length and mainly ascending. Often few on lower parts of canes.	Generally large, but varying seasonally.	Almost round.	Often crumbly.
Norfolk Giant.	Long ; slender ; seriously apt to break at the base.	Medium, sometimes large ; but often small in a dry year or late in the season.	Roundish to conical.	Firm.
St. Walfried.	Mainly short and strong ; numerous.	Large or very large.	Mainly long-conical, sometimes almost cylindrical.	Generally crumbly when under-ripe ; later very soft.

MODERN COMMERCIAL VARIETIES—FRUIT CHARACTERS.

FRUIT.			SEASON.	VARIETY.
Colour.	Flavour.	Picking qualities.		
Light red, fairly bright ; well maintained after ripening.	Good.	Conspicuous; easy to pick; will hang well when ripe without deteriorating.	Early to mid-season.	**Burnetholm Seedling.**
Medium red, bright ; darkening with ripeness.	Good.	Separates easily from the plug, but is often much hidden by foliage.	Early to mid-season.	**Lloyd George.**
Medium red, fairly bright ; sometimes darkening with ripeness.	Generally very good.	Conspicuous ; easy to pick.	Midseason to late ; slightly earlier than Norfolk Giant.	**Malling Enterprise.**
Bright red, seldom darkening.	Good.	Separates easily from the plug, but is often a little hidden by foliage.	Early.	**Malling Exploit.**
Medium red, fairly bright ; tending to darken slightly with over-ripeness.	Fairly good ; sweet.	Mostly conspicuous, although some berries are hidden by the rugose leaves of the laterals ; exceptionally easy to plug.	Early mid-season.	**Malling Jewel.**
Medium red, bright ; sometimes ripening unevenly, with a temporary green tip.	Fairly good.	Conspicuous ; generally easy to pick, but stalks sometimes break badly in dry seasons.	Early.	**Malling Promise.**
Light red, bright ; well maintained after ripening.	Variable, from sweet to distinctly acid.	Conspicuous, but often difficult to remove from the large, roundish plug.	Late.	**Malling Landmark.**
Medium red, bright ; generally well maintained after ripening.	Fair only; sweet.	Conspicuous; very easy to pick.	Second-early or midseason : short.	**Malling Notable.**
Light or medium red, bright, attractive ; well maintained after ripening.	Often very good.	Conspicuous ; easy to pick unless very crumbly ; will hang well when ripe without deteriorating.	Midseason to late.	**Newburgh.**
Medium red ; often dull but not dark.	Fair.	Conspicuous ; usually easy to pick, but stalks very apt to break when damaged by Cane Spot lesions.	Late ; fairly long.	**Norfolk Giant.**
Bright medium red at optimum picking stage ; later turning very dark.	Fair to good ; slightly acid.	Conspicuous ; easy to pick when barely ripe ; afterwards tending to adhere to the plug.	Early to mid-season.	**St. Walfried.**

Malling Enterprise (formerly Malling E, 33/132). **Fig. 3.** *References : Grubb* (1943) ; *Painter* (1948).

Raised at East Malling Research Station in 1932, from a cross between Preussen and a seedling derived from Lloyd George and Pyne's Royal.

This new variety has superior fruit quality, but in many soils produces canes too sparingly to carry a good commercial crop. Closer planting may possibly overcome this fault. It is usually an excellent garden variety, making tall, strong growth under sheltered conditions. It is deep-rooting and appears strongly resistant to drought. The fruit is fairly suitable for canning and quick-freezing, a fault being its tendency to darken when canned.

Malling Enterprise is not eligible for inspection under existing certification schemes. The best available stocks appear to be infected by certain viruses, yet show good vigour of growth (Cadman and Wood, 1951). It is susceptible to damage by the Raspberry Cane Midge (*Thomasiniana theobaldi* Barnes).

Malling Exploit (formerly Malling X, 51/84). **Fig. 4.** *Reference : Grubb* (1950).

Raised at East Malling Research Station in 1937, from a cross between Newburgh and a seedling derived from Lloyd George and Pyne's Royal. For details of this cross, which also produced Malling Promise, see Grubb (1946).

This variety closely resembles Malling Promise, but has proved the better in yield, fruit size, colour and dessert quality. Whilst neither variety has been favourably reported upon for canning, Malling Exploit appears from tests in Scotland to be much the better of the two for quick-freezing. It is not yet widely grown commercially, and the few stocks in distribution are believed to be of good health. A virus tested stock is under propagation.

Malling Jewel (formerly Malling J, 33/54). **Fig. 5.** *References : Grubb* (1943, 1950) ; *Painter* (1948).

Raised at East Malling Research Station in 1932. A sister variety to Malling Enterprise.

This variety has recently gained popularity in many parts of Britain, and has cropped consistently above the average in post-war trials in Scotland. It is liked for its erect growth habit, almost smooth canes, distinct ease of picking and good fruit quality. Flowering a little later than Lloyd George, St. Walfried, Malling Notable and other varieties, it is less liable to frost damage, yet is among the earliest varieties to ripen. The fruit is one of the best for canning and is acceptable for quick-freezing.

Stocks of Malling Jewel at present available are of similar health status to those of Malling Enterprise.

Malling Landmark (formerly Malling L, 34/42). **Fig. 6.** *References : Grubb* (1943) ; *Painter* (1948).

Raised at East Malling Research Station in 1933, from a cross between Preussen and Baumforth's Seedling A.

This variety shows outstanding cropping capacity, but the fruit is very soft-textured and generally of acid flavour. It is apt to spoil seriously in a wet season, and the berries are often difficult to detach from the plug. This last feature varies with season and locality, the indications being that the fruit is more acid in flavour and difficult to pick in Scotland than in the south of England. The canes are generally thorny, although in this, too, there is variation. Despite its high yield, it seems doubtful if this variety will gain a permanent place in the industry. The fruit is generally suitable only for the jam market.

Most commercial stocks of Malling Landmark are highly vigorous but not entirely free from virus infection. A virus tested selection has been raised, but the variety is not at present eligible for stock certification in Britain. It is highly susceptible to the fungus disease Cane Spot.

Malling Notable (formerly Malling N, 32/163). **Fig. 9.** *References : Grubb and Harris* (1947) ; *Painter* (1948).

Raised at East Malling Research Station in 1932, from a cross between Preussen and Lloyd George.

This variety generally yields only an average crop, but has done well at certain places in Scotland and the north of England. The fruit is firm enough for basketing, but on present information appears to be of only moderate quality for canning and quick-freezing. It gives a home-made jam of very good colour and texture.

Malling Notable is not eligible for official stock certification in Britain. The best stocks in commerce, though vigorous, appear to be wholly infected by certain viruses (Cadman and Wood, 1951).

Malling Promise (formerly Seedling 51/79). **Fig. 10.** *References : Grubb* (1946) ; *Painter* (1948).

Raised at East Malling Research Station in 1937, from a cross between Newburgh and a seedling derived from Lloyd George and Pyne's Royal.

This new introduction has already gained an important place in British raspberry growing. Its outstanding commercial characteristics are earliness and high yield, but although earlier than most other varieties in exposing leaves and flower buds, it seems distinctly resistant to injury by spring radiation frosts. It can, however, be severely affected by late air frosts. In Scotland it is grown mainly for the jam trade, particularly in the eastern area, where early ripening reduces the risks of a naturally late season. The fruit has not proved generally satisfactory either for canning or quick-freezing, and is considered too soft for the fresh fruit trade unless very carefully picked and transported for only short distances.

The majority of commercial stocks of Malling Promise may still be substantially free from virus infection, but certified stocks are preferable as sources of planting cane. A raspberry producing small, crumbly fruit, presumably either a seedling rogue or a bud-sport, has been noted in two fruiting plantations of this variety.

Newburgh. Fig. 7. *References : Howe* (1929) ; *Grubb* (1942).

Raised in 1922 at the New York State Agricultural Experiment Station, Geneva, New York, from a cross between the American varieties Newman and Herbert.

Much hope was entertained of this variety on its introduction to Britain in the middle 'thirties, but in southern districts it has proved highly susceptible to damage by the Raspberry Cane Midge (*Thomasiniana theobaldi* Barnes) and associated fungal infections (Pitcher, 1948, 1951). Nevertheless, it has generally been more successful in the south of England, where the Midge is prevalent, than in Scotland. It is sometimes said to do best in wetter localities. The fruit is liked for the dessert trade and by several jam manufacturers, but is too crumbly for canning or quick-freezing. Where this raspberry succeeds, it is possible that the Malling varieties derived from it may prove still better.

Every stock of Newburgh hitherto tested has been found infected by a certain group of viruses, but the variety appears to withstand considerable infection without loss of vigour. It is eligible for stock certification in England and Wales.

Norfolk Giant. Fig. 11. *References : Grubb* (1942) ; *Harris* (1944).

Originated as a chance seedling in the parish of Martham, near Great Yarmouth, Norfolk. Known as early as 1917, and said to have been generally introduced in 1922, becoming extensively grown first in East Anglia. First planted in eastern Scotland about 1928.

This well-known variety generally yields an average or fairly heavy crop. By flowering late it often escapes spring frost damage, but its late ripening is a disadvantage in Scotland owing to the chances of broken weather, or scarcity of pickers, after August. Plantation work is much obstructed by the spreading habit of growth of the new canes. The fruit is favoured both for canning and quick-freezing, and is rated highly for jam manufacture.

Norfolk Giant stocks are eligible for inspection under the certification schemes now in operation in Britain. Those free from visible virus infection may, for practical purposes, be considered healthy, since the variety expresses symptoms with nearly all the known raspberry viruses. It is very susceptible to the fungus disease Cane Spot.

St. Walfried. Fig. 8. *References : Grubb* (1942) ; *Rietsema* (1948).

Raised in Holland in 1926 by Dr. I. Rietsema, from a cross between Lloyd George and Hornet (almost certainly the Hornet A of Grubb, 1922). Introduced in Holland in 1931.

In recent years St. Walfried has been considerably planted in eastern Scotland, but although yields have often been high its general performance has varied, and plantations have often been slow to become established. It is seriously susceptible to spring frost injury. The tendency of the fully ripe fruit to adhere to the plug makes it necessary to pick this variety rather more frequently than others. The fruit, usually unsuitable for basketing, is grown mainly for the jam trade, where, however, its quality is not highly rated.

Although this variety is eligible for inspection under both the English and Scottish certification schemes, good stocks are scarce. Most commercial stocks are extensively virus infected and variable in performance.

Varieties of minor commercial importance.

Bath's Perfection. *References : Grubb* (1922) ; *Hedrick* (1925).

A variety widely grown in England in the nineteen-twenties, but now confined to very occasional garden cultivation. Still listed by some nurserymen. Generally considered identical with the old American variety Marlboro and the English variety Laxton's Abundance.

Baumforth's Seedling A. *References : Grubb* (1922). Baumforth's Seedling. *Flor. and Pom.*, 185 (1880). Baumforth I. *Hedrick* (1925).

A once valuable variety now only very occasionally found, chiefly in old gardens. Probably unobtainable in commerce. Fruit round or somewhat flattened ; juicy, acid.

Baumforth's Seedling B. *References : Grubb* (1922). Baumforth II. *Hedrick* (1925).

This variety, widely grown in the early 'twenties, has almost disappeared from commerce. It somewhat resembles Norfolk Giant in general appearance of growth. The fruits are conical, medium-sized and rather pale and dull, but very firm and of sweet flavour. Vigorous stocks are now scarce, but where obtainable it is an excellent raspberry for garden cultivation.

Carter's Bountiful.

A chance seedling found in a private garden at Stoke Poges, Bucks., and afterwards propagated by Messrs. Carters Tested Seeds, Ltd. Introduced in 1948. The circumstances of its origin suggested that it may have been derived from the old variety Superlative.

Chartham.

A chance seedling discovered in 1935 at Petty France Farm, Chartham, near Canterbury, Kent, and later propagated and fruited at Chapter Farm, Chartham, by Mr. A. G. Bird. Stock has been widely distributed since 1948, and the variety is being tried both commercially and in gardens, especially in the Chartham district. Fruit large, ripening late. Yield moderate. Too late and soft-textured for Scottish conditions, but said to travel satisfactorily in baskets in the south of England. Very susceptible to attack by the Raspberry Cane Midge (*Thomasiniana theobaldi* Barnes).

Devon. *References : Bunyard Cat.* 49 (1915/16) ; *Grubb* (1922) ; *Hedrick* (1925).

Raised by the late T. B. Pyne, of Denver Nurseries, Topsham, Devon, and introduced in 1904. Still grown commercially on a small scale in Devonshire, and very occasionally elsewhere, and much liked for garden cultivation in the south-west of England. Grown until recently in the Montrose area of Scotland as a canning raspberry. Vigorous stocks now unobtainable.

Hercules. *Reference : Grubb* (1942).

Introduced in 1937 by Messrs. Harraway, of Warminster, and now grown occasionally in commerce in England and Scotland. Sometimes produces too few canes for a full crop, and seems to require a rich soil. Fruit of good size, shape and colour, but with a large plug that leaves the berry hollow and easily flattened after picking. Yield moderate.

Hornet. *References :* Hornet A. *Grubb* (1922). Hornet (I). *Hedrick* (1925).

An old variety now displaced from commercial cultivation and very rare even in gardens. Reported at one holding in the south of England. Vigorous stocks unobtainable.

Laxton's Bountiful. *References : J. roy. hort. Soc.*, **37**, 561 (1911-12) ; *Grubb* (1922, 1942).

A raspberry now very seldom found. Grown until recently on a small scale in parts of East Sussex.

Matchless. *Reference : Grubb* (1942).

This variety was raised in Norfolk. Although for a time regarded as promising in the National Fruit Trials at Wisley, it became little adopted commercially.

Malling G (32/166). *References : Grubb* (1943) ; *Painter* (1948).

In quality of fruit, especially flavour, this is one of the better raspberries so far raised at East Malling Research Station. Owing to its limited cropping capacity it has not been released. A few stocks of fairly good health exist, and the variety can be recommended for garden use. Ripens in midseason.

Malling K (33/115). *References : Grubb* (1943) ; *Painter* (1948).

This variety also was given considerable trial, but eventually not released. It is rather poorer than Malling " G " in yield and quality, although in Scotland it has proved suitable for canning. Little material now exists.

Malling M (32/138). *Reference : Painter* (1948).

This seedling, which much resembles its sister-variety Malling Notable, has cropped well at East Malling and still better at places in Scotland, but has not been thought worthy of release. Material is now scarce. The fruit is suitable both for canning and quick-freezing.

Norwich Market.

This originated as a seedling selected by Mr. C. Mills, of Lingwood, near Norwich, and was distributed mainly by the late Frank Neave, of Lingwood. It gained commercial importance in the Norwich area, and at its best is said to have been a first-class raspberry in yield and quality. Existing stocks are virus infected and poor in vigour, but the variety is still favoured by some growers in its native locality.

Norwich Wonder. *References : Jour. Hort.*, **19**, 199 (1894) ; *Grubb* (1922) ; *Hedrick* (1925).

This is one of the oldest raspberry varieties still in existence. In 1894, according to the *Journal of Horticulture*, it had been grown in Kent for more than 60 years. Grubb tentatively identified it with a variety found in Perthshire under the name Laxton's Fillbasket, or Laxton. It has now almost disappeared from cultivation except in the Flegg district of Norfolk, where it occurs occasionally as an undercrop in old orchards. The fruit is early-ripening and of best dessert quality.

Preussen. *Reference : Grubb* (1942).

A German variety introduced to Britain in the early nineteen-twenties. Fruit large, with very good colour and flavour, but often distinctly soft in texture. Stools usually deficient in cane and apt to be short-lived, leaving rows gappy. This variety is now little grown commercially, but is a choice raspberry for the garden. Good stocks are scarce.

Pyne's Imperial. *Reference : Grubb* (1942).

Raised by the late T. B. Pyne, of Devon, and introduced in 1937. At its best, this variety gave very large fruit of excellent quality, but except on rich soils had always a tendency to form too few canes. Few healthy stocks remain, and the variety has largely disappeared from commercial cultivation except in parts of East Sussex, where its high quality and ease of picking commend it for the local dessert trade.

Pyne's Royal. *References : J. Pomol.*, **1**, 243 (1920) ; *Grubb* (1922, 1942) ; *Hedrick* (1925).

Raised by the late T. B. Pyne, of Devon, and introduced in 1913. Large-fruited like Imperial, and nearly its equal in quality, but with the same tendency to produce too few canes. Grown on a small scale in East Sussex, but elsewhere almost entirely displaced from commercial cultivation.

Park Lane. *References : J. Pomol.*, **1**, 243 (1920) ; *Grubb* (1922) ; *Hedrick* (1925).

Raised by the late T. B. Pyne, of Devon, and introduced in 1912. A raspberry of excellent flavour but light cropping capacity, which finds its best place in garden cultivation. Still listed by several nurserymen.

Red Cross. *References : Grubb* (1922, 1942) ; *Hedrick* (1925).

Raised by the late T. B. Pyne, of Devon, and introduced in 1917. Fruit large, juicy, and generally described as soft ; but said in some districts to travel well, and to hang on well after ripening. Still grown in the Dawlish area of Devon, and on a smaller scale by several growers in Norfolk and a few in East Sussex. Existing stocks are seriously virus infected and lacking in vigour.

Hybrid raspberries.

Natural hybrids between the Black Raspberry (*Rubus occidentalis* L.) and the American form of the Red Raspberry (*R. strigosus* Michx.) are well known in temperate North America, where both these species are native. Under the name of Purple-cane Hybrids, they were brought into cultivation and have been improved by breeding. The plants multiply by tip-rooting, and are generally vigorous and highly productive, with a juicy type of fruit varying in colour from light red to dark brownish-purple (Hedrick, 1925).

R. occidentalis is difficult to establish in Britain owing to its susceptibility to Verticillium Wilt disease, but Grubb (1948) has crossed this species with European raspberries (*R. idaeus*) to produce several purple-cane hybrid families. No selections have yet been named, but a number show high promise of providing valuable additions to the cane-fruits of this country, especially for garden culture.

Acknowledgements.

The writer is greatly indebted to Mr. N. H. Grubb, of East Malling Research Station, for his interest and help in the preparation of this paper. Grateful thanks are due also to Professor G. L. Slate, of Geneva, New York, Dr. I. Rietsema, of Breda, Holland, and Mr. J. M. S. Potter, of the National Fruit Trials, Wisley, for information and material. Information has also been supplied by

Miss J. M. Buttfield and Messrs. W. S. English, R. W. Kemp and F. A. Roach, of the National Agricultural Advisory Service, and by Messrs. A. G. Bird, L. J. Knight, G. W. Leak, W. H. Pyne, J. M. Saunders, J. N. Warnock and others. I wish to thank my colleague, Dr. C. H. Cadman, for taking the photographs illustrating this paper.

Acknowledgement is also made to the Agricultural Research Council, who financed this work.

Summary.

Descriptions and diagnostic characters are given of eleven raspberry varieties of commercial importance, together with notes on certain older varieties and on new ' hybrid ' raspberries.

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WIND RECORDS IN SOME KENT ORCHARDS

By A. P. PRESTON

Introduction.

In recent years many orchards have been planted on high land, to lessen the risk of frost damage due to the cold air which collects at lower levels during radiation frosts. Some experienced fruit-growers, however, have suspected a falling off in quality and quantity of fruit on farms above the 400 foot contour. Wind may be an important factor in such orchards although its effect may be less spectacular than late spring frost damage ; nevertheless, it can cause damage to foliage and may cause excessive fruit drop. Indirectly it may cause a poor fruit set by providing unsuitable conditions for the flight of pollinating insects. Efficient spraying, especially the proper timing of the scab sprays, may be difficult or even impossible in some years in windy situations.

To assess the magnitude and variation of the wind on some orchard sites, records have been taken during the past five years in some orchards in Kent situated at various altitudes. Brief notes on the topography of these orchards appear in Table I ; they include both hilltop and valley sites.

Methods.

Cup counter anemometers (Meteorological Office MK.II), recording the run of the wind in miles over the period of observation, were used. They were erected at a height of $25\frac{1}{2}$ feet on masts made from $1\frac{1}{2}$ inch gas piping secured by guy wires, readings being taken with field glasses. In 1951, similar anemometers were erected on stakes, at $4\frac{1}{2}$ feet above ground level, i.e. just below the main fruiting level of the apple trees between which they were placed.

Anemometer calibration.

Before the anemometers were erected in 1947, calibration graphs, received from the Meteorological Office, showed the corrections to be so small that they might reasonably be neglected, and the instruments were taken as reading correctly.

Since wind tunnel tests before and after each period of observation would have meant considerable delay, a method of field calibration was used in the second and subsequent years' trials. The anemometers were erected $4\frac{1}{2}$ feet above ground on stakes on a 24-foot grid in an open situation and were interchanged in position after periods of 24 hours. A double Latin square design was used to eliminate any positional effect. The numerical data were transformed to their logarithms and an analysis was carried out to test the differences for significance.

TABLE I.

TOPOGRAPHY OF ORCHARD SITES.

Site and anemometer reference letter.	Area.	Approximate height above mean sea level.	Approximate age of surrounding trees in 1951.	Remarks.
A	Faversham	140	15–20	Plain site. Whole area slopes gently northwards towards the Swale. Site was Soil Survey plot A (Rogers, 1946).
B	Bredgar	400	15–20	Hilltop site on nearly flat land. Site was Soil Survey plot B (Rogers, 1946). An exposed site.
C	East Malling	108	various	Plain site. On flank of low escarpment ; sloping gently northwards towards River Medway.
D	East Malling	96	7	
E	Larkfield	95	7	Hillock on a plain, outcrop of Folkestone Beds. This site is $\frac{1}{2}$ mile N.W. of site D.
F and F_1	Throwley	493	7	Hilltop site on nearly flat land 1 mile N. of Charing Hill. An exposed site.

Wind data during apple blossoming.

During this critical period readings were made daily. The mean daily run of wind for the various sites is shown in Table II and the daily run of the wind as shown by the anemometers, together with data on the time of blossoming of Cox's Orange Pippin, for the years 1948 and 1949, is shown in Figs. 1 and 2.

TABLE II.

SUMMARY OF WIND DURING APPLE BLOSSOM PERIODS.

Year.	Anemometer and site reference letter.	Height of anemometer above ground, feet.	Record period, days.	Mean daily run of wind, miles.	Per cent difference between sites for run of wind.	
1947	A	$25\frac{1}{2}$	14	141	A>B	3
	B	,,	,,	136	A>C	22
	C	,,	,,	109	B>C	19
1948	A	$25\frac{1}{2}$	23	139	B>A	13
	B	,,	,,	160	A>C	23
	C	,,	,,	107	B>C	33
1949	A	$25\frac{1}{2}$	19	185	A>C	10
	C	,,	,,	165		
1950	B*	$25\frac{1}{2}$	22	173	B>C	17
	C*	,,	,,	142		
1951	C	$25\frac{1}{2}$	41	175	F>C	32
	F	,,	,,	259	C>E	45
					F>E	62
	F_1	$4\frac{1}{2}$	,,	168	F_1>D	35
	E	,,	,,	96	F_1>E	42
	D	,,	,,	109	D>E	11

* Corrected figures.

Owing to faulty anemometers, no reliable data are available for site B in 1949 and for site A in 1950. The run of the wind recorded by anemometer B (Fig. 1) is probably lower than actually occurred since, when the instruments were calibrated in the field after blossom period, this was found to be reading 21 per cent lower than anemometers A and C. In 1950, the ratio between anemometers

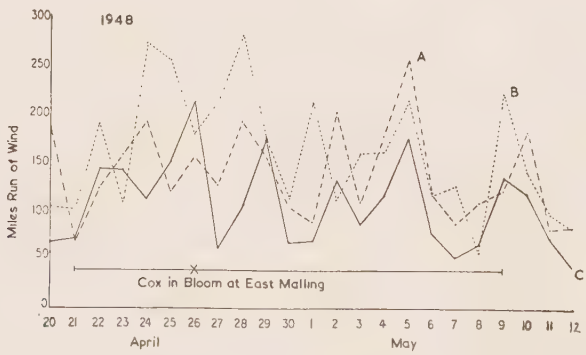

FIG. 1.

Daily run of wind in miles, as recorded during the blossom period on sites A, B, and C, 1948.

B and C when calibrated before and after the blossom period did not differ significantly, so it was possible to apply a correction with confidence. The corrected figures are given in Table II.

During the 1951 blossom period, anemometer C was compared with one erected at the same height above ground at site F, 493 feet above sea-level. Anemometers were also erected $4\frac{1}{2}$ feet above ground level among seven-year-old apple trees on sites D, E and F_1. Anemometers at F and

F_1 were approximately 100 yards apart. Sites D and E are ½ mile apart, but their topography is different (Table I). Anemometers D, E and F_1 were sited in the centre of the square formed by four trees, in the centre of each plot ; at a height of 4½ feet they were approximately level with the centre of the trees' heads, so giving some indication of the wind a young bearing apple tree has to withstand on these sites. When the anemometers were calibrated in April no significant differences were found, but in June, 41 days later, significant differences were found and the anemometers fell into two distinct groups, the brackets including those which did not differ significantly ($P = 0{\cdot}05$) :

Anemometer	D	F_1	F	E	C
Mean readings : April	95·0	99·7	90·1	102·2	96·8
„ „ June	62·8	65·2	69·3	69·4	71·9

Only the reliable comparisons between the anemometers at various sites are shown in the last column in Table II ; daily values for the run of wind as recorded by anemometers erected at 25½ feet and 4½ feet on various sites during the 1951 blossom period are shown in Fig. 3.

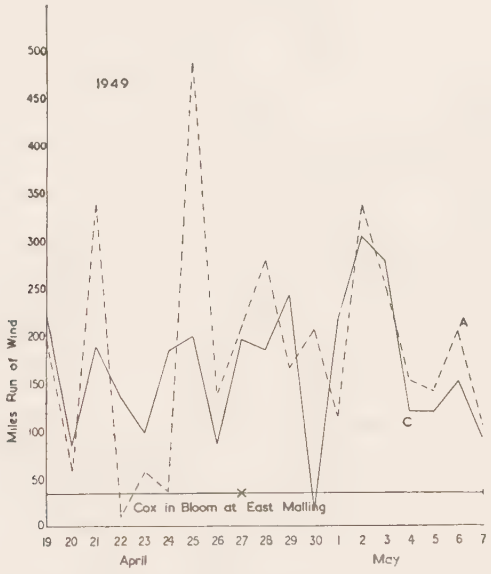

Fig. 2.

Daily run of wind in miles, as recorded during the blossom period on sites A and C, 1949.

Discussion.

Although mechanical breakdowns of the anemometers during the years 1949 and 1950 have prevented a four-year comparison of wind records on the three sites A, B and C during the apple blossom period, nevertheless, some general conclusions can be made on the data obtained. The consistently lower wind values recorded for site C are apparent, but, whereas in 1947 the wind recorded on site A was 3 per cent more than on site B, in 1948 the position was reversed, site B showing 13 per cent more wind than site A. From the anemometer calibration data already mentioned it seems that the difference recorded is probably lower than actually occurred.

The exposed orchard site F, situated on the top of the North Downs, gave much higher wind values during the 1951 season than site C. It is interesting, moreover, that the percentage differences between the values for the two sites obtained from anemometers at 25½ feet high (F and C) and for those at 4½ feet high (F_1 and D) in approximately the same positions are so close, about 33 per cent in both cases. It appears that the wind data from Crop Weather Stations can be used as an indication of relative amounts of wind *within* neighbouring orchards with fair confidence.

The value of cup counter anemometers of the type used in assessing the wind susceptibility of an orchard site appears to be limited, for the reliability of the instruments proved to be very variable. The commonest faults were due to rusting of the ball bearings of the main shaft, and the jamming of the counter wheels. The large changes in calibration that can occur in as short a period as 41 days are emphasized by the field calibration data. An expensive method of overcoming this limitation

would be three- or four-fold replication of anemometers at each site. A simpler method could perhaps be devised, e.g. using flags of standard composition whose disintegration over a short period could be measured.

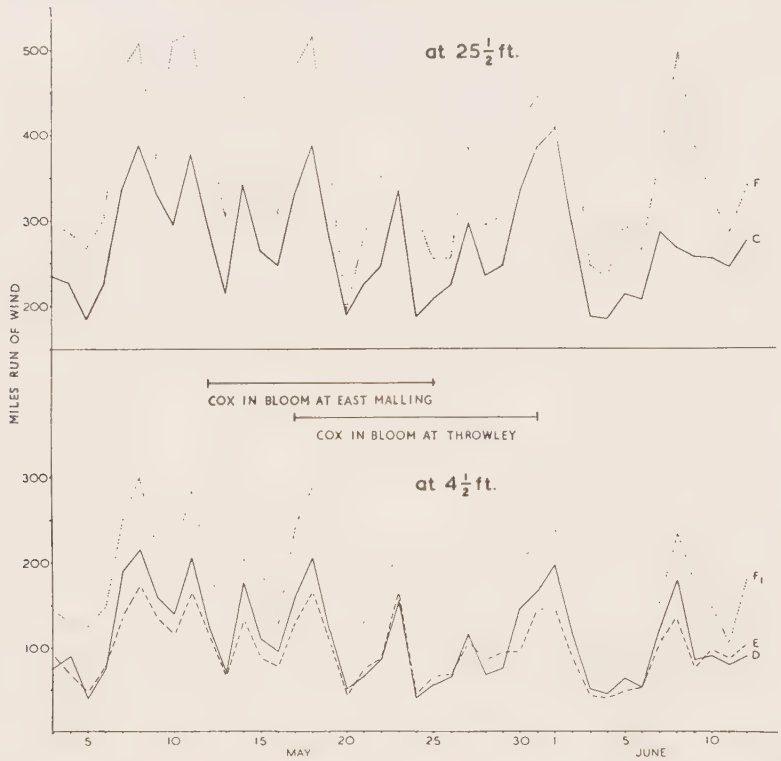

FIG. 3.

Daily run of the wind in miles, as recorded during the blossom period 1951, on sites F and C (anemometers at 25½ feet) and F_1, E, and D (anemometers at 4½ feet).

Acknowledgements.

The writer wishes to thank the growers concerned for their co-operation and also their managers, who kindly undertook to read the anemometers. Discussions with Mr. G. E. W. Hartley of the Meteorological Office have been most helpful. The Statistical Section assisted the writer in planning the anemometer field tests and carried out the analysis of variance on the calibration data.

Summary.

Cup counter anemometers, recording the run of wind, were erected in six Kent orchards situated at different altitudes and of varying topography.

A method of calibrating the machines in the field is outlined and wind data from orchard sites are shown for the five apple blossom seasons. The higher sites recorded higher values for run of wind which varied seasonally and according to the height of anemometer.

Data from anemometers at 25½ feet and 4½ feet above ground suggest that tall masts are unnecessary in establishing site differences for run of the wind in young orchards. The limitation of cup counter anemometers of the type used is stressed in relation to future work on wind susceptibility of orchard sites.

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WEATHER CONDITIONS DURING 1951

By A. P. PRESTON

The past year has been very wet, comparatively dull and characterized by a very late spring. The total rainfall for the year, 35·81 inches, was 9·71 inches above the average. This has been the wettest year since 1927 when 37·34 inches were recorded. Total sunshine was the lowest recorded since 1944. Soil temperatures were much lower than last year during the first six months of the year, and this possibly contributed to the lateness of the blossom season for top fruits (cf. time of blossoming diagrams for 1950 and 1951).

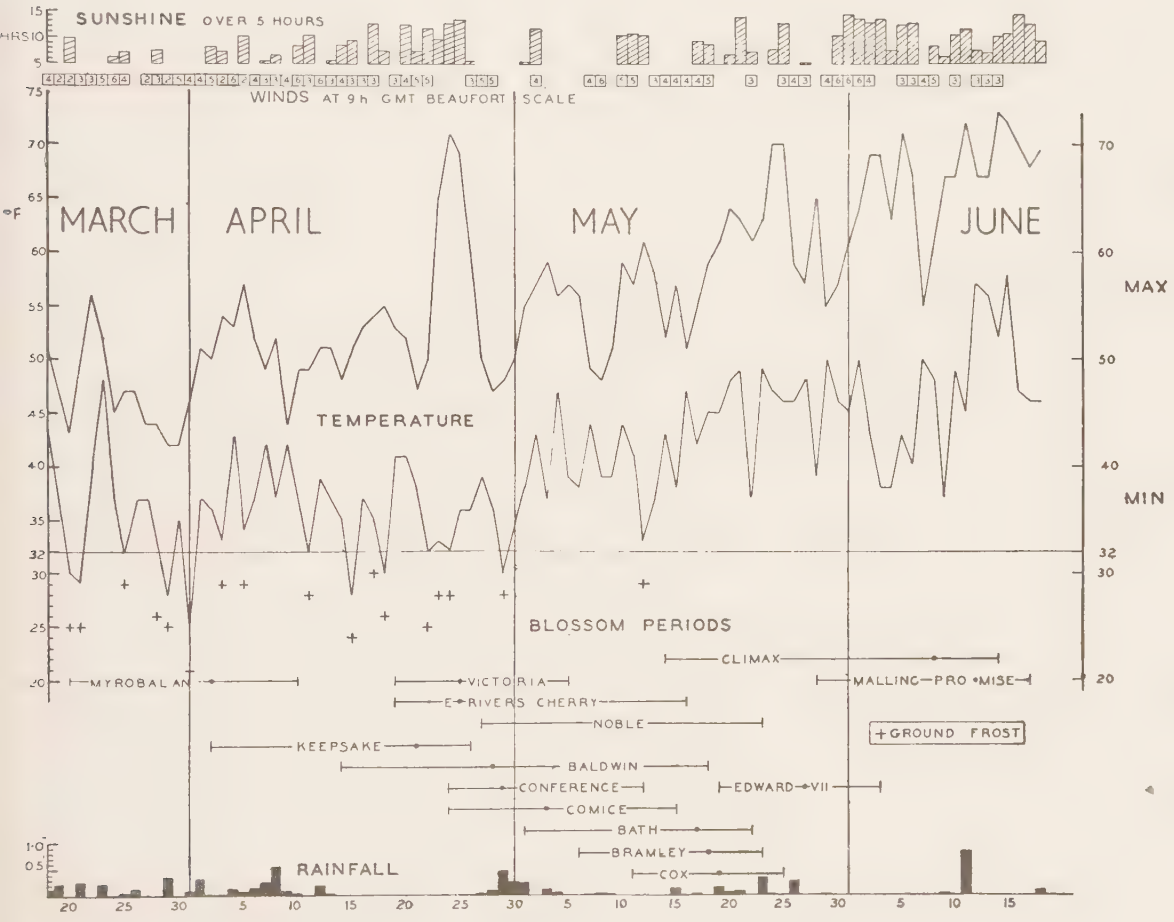

Diagram showing the weather recorded during the blossoming season, 1951.

Snow, sleet, or hail were recorded once during January, twice during February, and five times during each month of March and April. The snow persisted during the first two days of January only.

Rain was recorded on 24 days during February, and the total for the month of 5·90 inches creates a record for this month at this Station since our records began in August, 1914.

Serious late spring frosts were again absent this year, the lowest screen minimum during May being 33° F., recorded on the 12th.

June, a sunny month, had a rainfall of 1·31 inches, recorded on only 8 days. July, also a sunny month, had a rainfall of 2·79 inches, recorded on 9 days. The heaviest rainfall of the year was recorded this month when 1·45 inches fell during the evening of the 12th. The highest screen maximum temperature of the year, 81° F., was recorded on the 28th.

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1951.

East Malling.

Month.	Temperature in Screen.					Number of Ground Frosts.	Rainfall.			Sunshine.			Soil Temperatures.			
	Mean maximum.	Mean minimum.	Highest.	Lowest.	Mean.		Total in inches.	Heaviest fall in a day.	35* years' average.	Total hours.	Average per day.	25 years' average.	4 inches.	8 inches.	2 feet.	4 feet.
January	46	35	52	22	40	13	2·66	0·71	1·96	47·3	1·5	47	37·7	38·2	39·9	41·8
February	45	34	52	24	39	14	5·90	1·01	1·85	56·7	2·0	68	36·7	37·2	39·4	41·3
March ..	47	35	56	25	41	12	3·37	0·83	2·01	98·3	3·2	123	39·1	39·5	41·4	42·1
April ..	52	36	71	28	44	10	2·92	0·56	1·65	193·4	6·4	152	44·7	43·8	45·1	44·4
May ..	58	43	70	33	50	1	1·65	0·35	1·67	168·8	5·4	200	51·7	50·4	50·4	48·3
June ..	67	48	73	37	57	0	1·31	0·82	2·04	256·7	8·6	222	61·5	59·7	58·9	54·8
July ..	73	52	81	43	62	0	2·79	1·45	2·19	227·8	7·3	208	66·0	64·4	63·7	59·4
August ..	68	51	75	45	59	0	3·69	0·76	2·19	169·4	5·5	194	61·5	60·9	62·3	60·5
September	66	51	74	37	58	0	3·91	1·21	1·98	120·3	4·0	147	58·1	58·1	59·8	59·1
October	57	40	66	28	48	8	1·05	0·26	3·11	112·5	3·6	105	48·4	49·4	52·9	54·9
November	53	41	60	29	47	7	4·35	0·64	2·79	60·3	2·0	55	45·0	45·6	48·2	50·3
December	48	36	53	20	42	13	2·21	0·60	2·66	51·1	1·6	42	39·9	43·8	43·3	46·3
Totals ..						78	35·81		26·10	1562·6		1563				

Sub-Station, Newlands Farm, Throwley.

January		35		22		11	3·70	1·11		51·8	1·7		37·4	38·0		42·2
February		34		30		10	6·68	0·98		64·0	2·3		36·6	37·2		41·8
March ..		35		27		14	3·58	0·88		113·4	3·7		38·1	39·0		41·8
April ..		37		31		10	2·39	0·33		206·7	6·9		43·3	43·1		43·3
May ..	56	44	67	37	50	2	2·40	0·52		172·1	5·6		49·8	49·5		46·6
June ..	64	49	72	42	56	0	1·64	0·96		274·2	9·1		59·2	58·4	57·1	52·2
July ..	71	53	79	44	62	0	1·79	0·50		260·9	8·4		64·1	63·4	61·7	57·0
August ..	66	52	74	47	59	0	4·35	1·43		171·9	5·5		60·8	60·8	61·3	58·8
September	64	52	72	43	58	0	4·23	1·24		122·9	4·1		57·7	58·3	59·4	58·0
October	56	44	62	32	50	10	1·69	0·59		117·2	3·8		49·8	51·1	53·8	55·3
November	52	43	58	29	47	6	4·76	0·66		61·5	2·1		46·0	46·7	49·2	51·2
December	47	38	51	26	42	8	3·28	0·94		61·6	2·0		41·4	42·0	44·7	47·7
Totals ..						71	40·49			1678·2						

* Weighted averages for the 35-year period 1881-1915, as used in the Monthly Weather Report of the Meteorological Office.

August and September, both wet months, each had rain on 17 days. September, with a rainfall of 3·91 inches, is the wettest since 1927, when 4·76 inches were recorded.

October was a comparatively dry month and November very wet, the 4·35 inches recorded during that month fell on 23 days. No snow was recorded during December this year.

Thunderstorms were recorded 11 times during the year and were most frequent during June.

Newlands Farm, Throwley.

This crop weather station, a sub-station of East Malling, has acquired the full complement of instruments during the year. The rainfall recorded at this Station was 4·68 inches higher than at East Malling, and the sunshine values were higher by 115·6 hours. It will be seen that the mean maximum temperatures are lower than at East Malling, while the mean minima are higher.

Acknowledgements.

The writer wishes to thank Mr. G. F. Trowell for assistance during the year, and members of the Statistical Section who assisted in computing the data and preparing the diagram. Mr. J. Cronk (by courtesy of T. Neame, Esq.) was responsible for records at Newlands Farm, and his co-operation is gratefully acknowledged.

MICHAELMAS RED—A NEW DESSERT APPLE

By H. M. TYDEMAN

A new apple variety, Michaelmas Red, will be made available to our members during the coming winter in the hope that it may prove of value as a commercial dessert apple to follow Worcester Pearmain. Derived from a cross between Worcester Pearmain and McIntosh Red, it was raised in 1929 during attempts to produce a series of new apple varieties of appearance similar to the former and covering an extended season.

In general appearance the fruits of Michaelmas Red bear a superficial resemblance to those of Worcester Pearmain, being of a deep red colour over a creamy yellow ground with a slight whitish bloom when freshly picked. The colour is usually of a darker red than that of either of its parents, but samples from different soils have varied in this respect. The fruits are very even in shape, somewhat less conical than those of Worcester Pearmain, but with the characteristic ' Worcester eye '. The fruits may tend to be a little small when crops are very heavy ; they mature during late September and early October, immediately after Worcester Pearmain is finished. Although the natural season does not appear to be very long, small samples kept in cold store have remained in excellent condition until December. The fruits are crisp and juicy, with a pleasant although not outstanding flavour. In texture they are less hard than the Worcester Pearmain and have been reported as superior to the latter in flavour and juiciness.

Frameworked trees of Michaelmas Red that have been under observation at East Malling for more than 20 years have not shown any unusual susceptibility to pests or diseases and have been subjected to all the usual orchard spray routines without any ill effects. The variety has made satisfactory trees both framework grafted and worked directly on to M.I, II, IV and VII, and has cropped early and regularly. The shoots furnish very readily with spurs and the variety is a decided improvement on Worcester Pearmain in this respect. It is very similar in season of flowering to the latter and blossom has set well under a wide variety of conditions.

It must be remembered that it is not possible to assess completely the suitability of a new introduction for commercial culture on the basis of preliminary trials, and that an adequate verdict can only be reached by pooling over a long period, the experiences of practical growers. There is, however, sufficient evidence to justify the conclusion that Michaelmas Red is worthy of trial by those who are looking for a dessert apple of the Worcester class to be marketed during the late autumn. It has received commendation from fruit salesmen and retailers to whom it has been submitted and, although not of outstanding dessert quality, may well find a place among varieties of commercial value.

Summary

Details are given of Michaelmas Red, a new dessert apple raised at East Malling from a cross between Worcester Pearmain and McIntosh Red, which is to be distributed to members during the coming winter. The characters of the variety are briefly described.

STATISTICS

STUDIES IN THE MEASUREMENT OF APPLE TREES

I. THE USE OF TRUNK GIRTHS TO ESTIMATE TREE SIZE

By S. C. PEARCE

Introduction.

The girth of trunk of a tree is one of the most obvious measurements of its size as well as one of the easiest to make. Thus, Chaturvedi (1926) cites instances of its use in forestry as long ago as 1804. On fruit trees it is measured for one of two reasons, either to indicate future crops (Sudds and Anthony, 1928 ; Wilcox, 1940 ; Pearce, 1949) or to estimate tree weight. It is only the second of these that will be considered here.

Opinion as to its value for this purpose has for long been divided. Thus, Sudds and Anthony (1928) asserted that " trunk and branch circumference are so closely correlated to weight and elongation, that usually they are the only records which need be taken in studies of apple tree vigour ". On the other hand, Hoblyn (1931), while recommending trunk girth as a standard record, wrote " No single measure is ever sufficient to describe the vigour of a particular tree."

Several attempts have been made to elucidate the relationship between trunk girth (G) and tree weight (W). Thus, working with trees four years after planting, Heinicke (1921) found that doubling G multiplies W by 7·3, which would be true if the relationship were $W=AG^{2\cdot87}$ where A is a constant. Knight and Hoblyn (1934) after examining records on young apple trees asserted that W increases more rapidly than G^2 and less rapidly than G^3—actually their data are well fitted by $W=AG^{2\cdot6}$; while those of Collison and Harlan (1930) relating to mature standard trees conform well to the relationship, $W=AG^{2\cdot65}$. Considering the very different sorts of trees used in these investigations, the agreement is good ; but it remains to be shown whether or not the relationship is upset by the application of differential treatments, as Tukey and Brase (1938) have suggested is probable.

The present approach.

Suppose the relationship is, in fact, of the form $W=AG^b$ (Huxley, 1924) where b is constant for a given set of trees. Then (writing small letters for the logarithms of the corresponding capitals) it follows that $w=a+bg$, where w and g are normally distributed (Pearce, 1943). This is the relationship studied by Welch (1935), who has described methods for (i) testing if b is affected by treatments and (ii) testing a similarly, supposing b to have been shown invariant by the first test. He has also described a necessary preliminary test to find out if the data are suitable for such a study. In the present investigation, b has been evaluated for several sets of data and tests have been applied to find out if it and a have been affected by treatments, the preliminary test having first been applied.

Material.—Data were available from six trials, three for the comparison of clonal rootstocks (*R1-3*), one of pruning methods (*P*) and two of manurial treatments (*M1-2*).

R1. Seventy-eight trees of Bramley's Seedling, 16 years old, six on each of the rootstocks M.I-M.XVI, omitting M.VIII, M.XI and M.XIV. On M.IX there was considerable scion-rooting.

R2. One hundred and four trees of Worcester Pearmain, 14 years old, eight on each of the rootstocks used in *R1*. On M.IX there was a little scion-rooting.

R3. Sixty-four trees of Cox's Orange Pippin, 23 years old, eight on each of the rootstocks M.I, M.II, M.III, M.V, M.VI, M.IX, M.XIII and M.XVI.

P. Thirty-two trees of James Grieve, 22 years old, on mixed Paradise rootstocks. For the first nine years after planting eight were unpruned, eight regulated, eight short-spur pruned and eight long-spur pruned. The unpruned trees were then thinned out, an operation that was repeated two years later, and thereafter all trees were regularly leader tipped.

M1. Thirty-two trees of Cox's Orange Pippin on M.IX, 19 years old, in sixteen pairs of which eight had received each year 2 cwt. of sulphate of potash per acre more than the others.

M2. A similar set of Beauty of Bath on M.IX in which, however, the level of phosphatic manuring had been higher throughout.

All ages are measured from the time of budding, not the time of planting. All trees were planted as one-year-olds, except those of trials *M1* and *M2*, which were two years old when planted. The

root systems of trees in trials *R1* and *R2* have been described elsewhere (Bane, Beard and de Wet, 1935).

Data.—On all trials except *P* records were available of the trunk girth 9 inches above the graft union and of the weight of tree above ground, both made at the time of lifting. For *P* the girth was measured at lifting at the level of the minimum girth at 9 years of age. The weight used was that of the whole tree including such roots within a constant radius of the trunk as could be removed with the trunk at grubbing.

Results.

In order to satisfy the preliminary test for the suitability of data, it was necessary to omit the Cox's Orange on M.IX (*R3*), and the short-spurred James Grieve (*P*). The former were omitted because of the low correlation between *g* and *w*, possibly due to swellings above the union common in trees on M.IX. The latter, on the other hand, showed a higher correlation than did the other treatments, for which no explanation is apparent. All other data were acceptable.

Correlation.—In general, *g* and *w* were highly correlated, the coefficients being +0·946 (*R1*), +0·951 (*R2*), +0·979 (*R3*), +0·808 (*P*), +0·948 (*M1*) and +0·947 (*M2*), after the elimination of differences between rootstocks and treatments. In the manurial trials, the differences between pairs of trees were eliminated also.

Such correlations do not necessarily show that girth is an adequate means of estimating weight, for it must be demonstrated also that *a* and *b* do not depend upon the treatments.

TABLE I.

RELATIVE WEIGHTS OF TREE FOR DIFFERENT ROOTSTOCKS WITH STANDARD TRUNK GIRTH (M.I=100).

Rootstock.	Trial.		
	R1.	R2.	R3.
M.I	100	100	100
M.II	94	104	107
M.III	88	108	98
M.IV	99	109	—
M.V	94	98	102
M.VI	101	93	95
M.VII	101	102	—
M.IX	110*	120†	—
M.X	98	98	—
M.XII	102	125	—
M.XIII	118	112	127
M.XV	96	99	—
M.XVI	114	128	133

* Considerable scion-rooting.

† Slight scion-rooting.

Comparison of values of b.—For no trial was there any reason to believe that the treatments, whether of rootstocks, manures or pruning, had altered the value of *b* within a trial. These values, which were 2·67 (*R1*), 2·27 (*R2*), 2·67 (*R3*), 1·92 (*P*), 2·66 (*M1*) and 2·76 (*M2*), differ, however, considerably among themselves. Thus in the rootstock trials the three scion varieties gave significantly different results ($P<0·01$), possibly because of the markedly different habit of Worcester Pearmain (*R2*) as compared with the other two. In confirmation of this effect of scion variety on the value of *b*, it will be seen that the two trials with Cox's Orange Pippin (*R3* and *M1*) gave very similar values. The results for Trial *P* are associated with a low correlation coefficient and will receive special consideration in the discussion.

Comparison of values of a.—It was evident that *a* was materially affected by rootstocks, the differences being highly significant ($P<0·001$) for each of the trials, *R1-3*. Further, there was good general agreement between them, as is shown in Table I, wherein are compared the relative weights of trees on different rootstocks supposing them all to have the same girth, M.I being assigned a weight of 100. Although agreement is not perfect, it is clear that M.IX, M.XIII and M.XVI, despite their diversity in vigour, all give a tree that is heavy for its girth, while some others, e.g. M.V, M.VI, M.X and M.XV, form a light one.

For Trial *P* also, *a* was markedly affected by treatments ($P<0·01$). For trees of a standard

girth, taking the unpruned ones to have a weight of 100, the weight of those long-spur pruned was 117 and of the regulated 126. In the manurial trials (*M1* and *M2*) there was no suggestion of the treatments having affected *a*.

Discussion.

If trunk girth is used to estimate tree weight in an experiment, it is important, not only that the two should be highly correlated, but that the relationship between them should not itself be dependent upon the kinds of trees or their treatments. In this study four kinds of differences have been considered—those due to scion varieties, rootstocks, pruning and manuring —with different conclusions for each.

Manuring.—Since both *a* and *b* are independent of the treatments, it follows that the relationship subsisting between the quantities, *g* and *w*, in a series of uniformly treated trees subsists also where there are differential treatments. Consequently, any differences induced in girth will correspond to differences in weight also. It should be emphasized, however, that the only manurial differences considered here were in the quantity of potassic fertilizer applied and, although this affected total growth more than is usual with fertilizers, the conclusion does not necessarily apply for other manurial differences.

Pruning.—The low correlation between *g* and *w* in Trial *P* was doubtless the cause of the low value of *b*. Two reasons can be suggested for it :

(1) Both girth and weight were measured less satisfactorily than in the other trials, the weight including a variable proportion of the root system.
(2) The non-clonal stocks must have caused *a* to vary within treatments, thus obscuring the relationship.

Nevertheless, the difficulties make more striking the significant effect of pruning methods upon *a*.

Although it is desirable that the relationship of the two quantities should be independent of treatments, pruning may present an exception to this. Given a uniform method of pruning, treatment differences are a matter of degree and it may well be that treatments giving greatest girth give the largest values of *a*. If so, a difference in mean *g* would indicate a definite, though unmeasured, difference in *w* also. Further information would be needed to prove this.

Rootstock.—It is clear that an unsupplemented record of girth is not enough to indicate the differences brought about by various rootstocks. The reason almost certainly lies in the varying balance between the two forms of growth activity in a woody plant (viz. the making of new extension growth and the thickening of growth already made) being itself one aspect of the habit of the scion as affected by the rootstock. If some simple measure of this balance could be found for each particular rootstock, the estimation of weight differences might well become practicable.

Scion variety.—Although none of these trials was designed to investigate the effect of scion on the relationship, there is reason to think that each variety has its characteristic value of *b*. If so, weight comparisons between them on the basis of girth are almost impossible. It may even be that at one standard girth, variety A may have the greater weight ; but at another B may be the larger.

Summary.

A study is made of the relationship between trunk girth and tree weight in a series of trials of bush apple trees with a view to estimating one by the other. In manurial trials, at least with varying amounts of potash, trunk girth is an adequate measure for estimation of tree weight. In trials of rootstocks and pruning treatments there is reasonable hope that further research will suggest a method of estimation, but not for trials comparing different scion varieties.

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THE DESIGN OF CALIBRATION TRIALS WITH THREE VARIETIES

By S. C. PEARCE

In a previous paper (Pearce and Taylor, 1950) designs were suggested for calibration trials, i.e. plantations intended to be used experimentally after a preliminary period spent in determining the performance of individual trees. These were of two main types, tile designs and stripe designs, only the latter being available when the varieties numbered three. In this paper, two tile designs will be described for use with this number of varieties.

Tile I.

In this design the tile is like this :

```
Z  Z
X  Y        Direction of rows
Z  Z        ------------------>
Y  X
```

Thus, in Fig. 1 this tile appears first in the top left-hand corner and is repeated both along the rows and across them until the area is filled.

A plantation laid out thus can be divided into plots in three ways as shown in Fig. 1, there being further possibilities if all trees of Variety Z are used as guards or, alternatively, all trees of Varieties X and Y. In the first two of these ways there are four trees to a plot, including two of Variety Z ; guard rows may be used or not as desired. In the third, which has few advantages for unguarded plots, though it is often best for guarded ones, each variety is represented only once in each plot.

For unguarded plots there is little to choose between the first two ways and preference in particular instances will depend upon convenience and the desirability of using blocks as compact as possible. For guarded plots, however, it will be found that the first is usually less economical of trees. As the size of the plantation increases, the proportion of trees available for experimental purposes will tend to 40·0 per cent for the first and to 44·4 per cent for the second. The corresponding figure for the third is only 37·5 ; though, as the plots are smaller, more can usually be fitted into any given space. In fact, if the duplication of Variety Z is not serving any useful purpose the third way is the best for guarded plots.

In designing such trials, it is advisable for one, if not both, of the outside rows to be made up of Variety Z, for this enables the third method of forming plots to be used to best advantage without doing harm if one of the other methods is used instead. For the rest, the recommendations for tile designs with four varieties apply here without major modification.

Tile II.

In this design, which is illustrated in Fig. 2, the tile is a 3 × 3 Latin square, which appears in the top left-hand corner of the plan and is repeated both across and downwards to fill the space available. This results in the varieties being planted in rows diagonally across the trial.

There are three ways of forming plots that can be used either with or without guard rows. There is a fourth that can be used only with guards, but allows the duplication of one variety if this is needed for some subsidiary investigation. All these methods are shown in Fig. 2, from which it will also be apparent that the removal of alternate trees in alternate rows does not alter the basic design. In the second method, which uses triangular plots, it is important that the hypotenuse of each triangle should be at right angles to the rows of varieties running diagonally across the plantation.

With unguarded plots the first and third methods are to be preferred on the grounds of simplicity, though sometimes the second enables trials to be fitted in better on the trees available. There is nothing to choose between the three of them on the score of economy.

When guards are needed, the second is commonly the most economical, the proportion of trees available for experimental purposes in large plantations tending to 37·5 per cent for the first and third methods and to 40·0 per cent for the second. For the fourth the percentage is 44·4, but the gain would be worth while only if advantage could be taken of the duplication of one of the varieties. Although economical, the second method is not a particularly good one because triangular plots can be very awkward for the farm staff.

DESIGNS USING TILES I AND II.

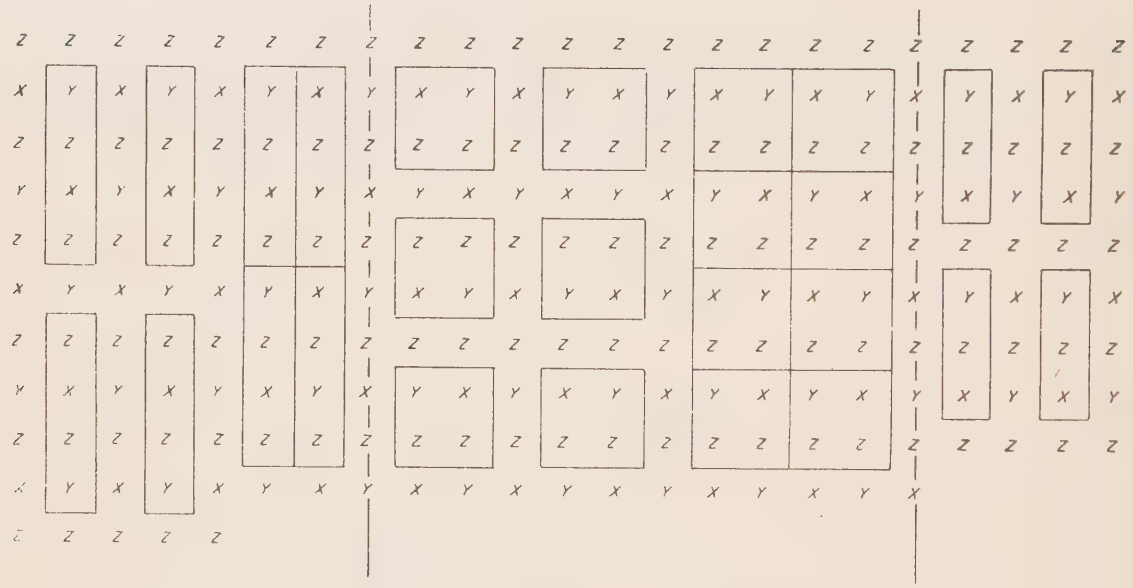

FIG. 1.

Possible way of forming plots when Tile I is used.

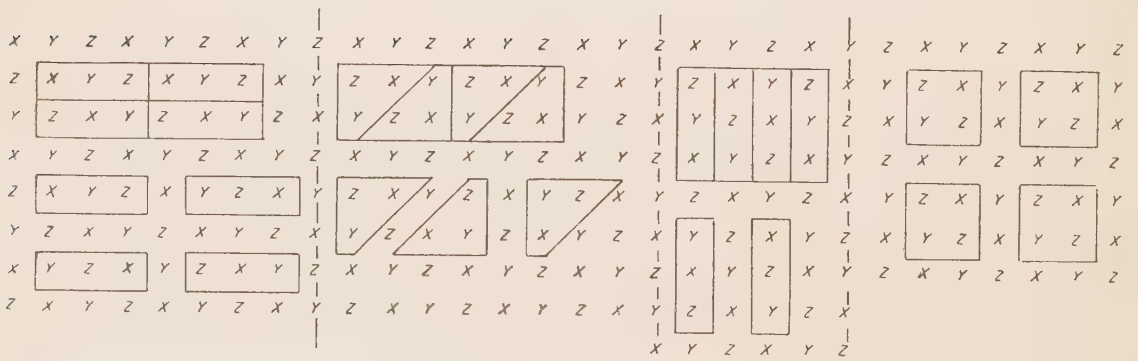

FIG. 2.

Possible way of forming plots when Tile II is used.

When designing such a plantation, it is first necessary to decide whether or not triangular plots can be tolerated. If they can, it is advisable to use rows to the number of $(3m + 1)$, where m is some whole number, for this permits without waste the first method of forming plots if they are not guarded and of the second and fourth if they are. Assuming these methods to be the chosen ones, it will be found that 17, 21, 26, 32 or 47 trees to a row give a lay-out in which few trees will have to be wasted even in the most unfavourable cases. If triangular plots are to be avoided at all costs, it is best to adopt the first method of forming plots as standard. This ideally requires an odd number of rows, the trees to a row numbering $(12m - 7)$, where m is some whole number. In this way, wasted trees can be wholly avoided whether plots are guarded or not.

It will be noticed that the variety duplicated in plots formed by the fourth method can be selected at will. In Fig. 2 each plot contains two trees of Z, but if the plot boundaries are moved one tree to the right it is X that is duplicated, while if they are moved to the left it is Y. In a particular lay-out, however, one of these is likely to be more convenient and economical than the other two.

Acknowledgement.

The writer is indebted to Mr. T. N. Hoblyn for help in the development of Tile II.

Summary.

Two designs of tile for calibration trials with three varieties are described.

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PLANT PHYSIOLOGY

USE OF SPRAYS TO CONTROL FRUIT DROP

VIII. FURTHER TRIALS WITH NAA SPRAYS ON THE APPLE VARIETY BRAMLEY'S SEEDLING

By M. C. VYVYAN and G. F. TROWELL

Introduction.

Trials with α-naphthalene-acetic acid (NAA) sprays to control pre-harvest drop in Bramley's Seedling apples have met with little success as yet, but it is desirable to know if such sprays will control the earlier June drop or the heavy late drop that ensues when picking is delayed. Trials on these lines were carried out in 1949 and 1950 and are described in this report. The dropped fruits were separated into ' sound ' and ' unsound ' ; the percentages presented in the tables in this report have been based on ' total ' fruit numbers, i.e. ' sound ' plus ' unsound '. The principal causes of damage to the latter class were Codling attack and Brown Rot.

The effect of adding NAA to routine sprays applied in May and June, 1949.

Trials with Cox's Orange Pippin have indicated that the effectiveness of NAA is not reduced when it is added to a routine spray of lead arsenate or dispersable sulphur (Vyvyan and Barlow, 1948) ; results of adding it to lime-sulphur were inconclusive (Vyvyan and Trowell, 1951). In the trial with Bramley's Seedling, therefore, it was decided to add the NAA to the routine sprays. The trees used formed part of a plantation of mature Bramley's Seedling and received three protective sprays ; lime-sulphur plus nicotine on 16th May and mercurated lead arsenate plus derris on 31st May and 21st June. Alternate trees in alternate rows were used, arranged in 10 blocks of six trees. One tree at random in each block received NAA in the first spray (16th May), another in the second (31st May), a third in the third (21st June), the fourth tree received NAA in all three sprays and the remaining two trees received no NAA and constituted the control. The three sprays were applied at the rates of approximately 7½, 9½ and 8 gallons per tree respectively. A little rain fell in the night and morning after the first spray.

TABLE I.

EFFECT OF ADDING NAA TO ROUTINE SPRAYS OF LIME-SULPHUR AND MERCURATED LEAD ARSENATE, APPLIED IN MAY AND JUNE, UPON PERCENTAGES OF FRUITS DROPPED AND PICKED, 1949.

Treatment.	No. of trees.	Spray.†			Percentage dropped* up to :					Percentage picked* on 17th Oct.
		16th May. LS.	31st May. ML.	21st June. ML.	13-14th July.	27th July.	24-25th Aug.	15-19th Sept.	17th Oct.	
1	10	NAA	——	——	10	12	15	19	32	67·9
2	10	——	NAA	——	9	11	14	19	37	63·3
3	10	——	——	NAA	12	14	16	20	34	65·9
4	9	NAA	NAA	NAA	10	11	14	20	35	64·9
5	20	——	——	——	10	12	16	20	35	64·8

* Based on estimated total numbers of fruits on trees on 30th June.

† LS Lime-sulphur 1 gal., nicotine 8 oz., per 100 gallons.
ML Mercurated lead arsenate 2 lb., derris 2 lb., per 100 gallons.
NAA α-naphthalene-acetic acid 10 parts per million.

The ground under the trees was cultivated and cleared of earlier drops on 30th June and subsequent drops were collected and counted on 13th-14th July, 27th July, 24th-25th August, 15th and 19th September and 17th October. The September collection, started on the 15th, was interrupted by rain and was completed on the 19th. The last collection included the fruits dropped or knocked off during picking, which was carried out on 17th October.

The final number and weight of apples per tree were estimated by selecting two or more boxes, at random, under each tree, counting and weighing the fruits they contained, and multiplying these values by the number of boxes picked from that tree. Part-filled boxes were estimated by eye to the nearest quarter box.

The number of fruits on each tree on 30th June was estimated by summing the number of drops and the estimated number picked. The values for accumulated percentage dropped and percentage picked, presented in Table I, are based on these estimates. The values for treatment 4, the trees that received NAA on all three occasions, are based on those for only nine trees, because boxes of picked fruits from one tree were removed in error by the pickers, before they had been recorded. In no column are there important differences between treatments.

The mean daily rate of drop during successive periods, calculated by the logarithmic method (Vyvyan, 1946), is shown in Table II. Where the collection was spread over more than one day, the convention has been followed of allocating them all to the first day. The daily loss per 1,000 fruits in the control trees was about eight during the first fortnight of July, some six or seven during the last month before picking, but only one or two during the intervening two months from mid-July to mid-September. The values for the experimental trees do not differ materially. The last two columns in Table II give the estimated crops per tree and the weights per 100 fruits; again there are no important differences between treatments. As no records of drops were made before 30th June—six weeks after the application of the first NAA spray—any differences in the rate of drop before that date will have passed unnoticed; moreover, such differences would tend to introduce a bias into the values for the percentages shown in Table I, since these were based on the estimated numbers of fruits present on the trees on 30th June. The values for rate of drop in Table II, however, are not subject to any such bias—an advantage of the logarithmic method—and they tend to confirm those in Table I. The values for mean crop provide further confirmation.

TABLE II.

MEAN DAILY PERCENTAGE RATE OF DROP, PERIOD BY PERIOD, AND CROP, 1949.

Treatment.	No. of trees.	Spray.† 16th May. LS.	31st May. ML.	21st June. ML.	Mean daily rate of drop.* 30 June to 13 July.	13 July to 27 July.	27 July to 24 Aug.	24 Aug. to 15 Sept.	15 Sept. to 17 Oct.	Crop per tree, lb.	Weight per 100 fruits, lb.
1	10	NAA	——	——	0·80	0·19	0·12	0·23	0·58	472	25·4
2	10	——	NAA	——	0·72	0·13	0·13	0·30	0·78	422	26·3
3	10	——	——	NAA	1·02	0·14	0·11	0·18	0·62	433	21·2
4	9	NAA	NAA	NAA	0·81	0·12	0·11	0·32	0·66	404	27·9
5	20	——	——	——	0·83	0·18	0·13	0·23	0·66	454	25·0

* Based on estimated total numbers of fruits on trees on 30th June.

† LS Lime-sulphur 1 gal., nicotine 8 oz., per 100 gallons.
ML Mercurated lead arsenate 2 lb., derris 2 lb., per 100 gallons.
NAA α-naphthalene-acetic acid 10 parts per million.

Effect of a late NAA spray and of a delay in picking on crop.

1949 Trial.

Sixty mature trees in the same plantation were used, the lay-out of the trial being the same as described above. Three random trees in each block were sprayed with NAA at 10 parts per million, about 15½ gallons of spray being used for each tree. The remaining three trees were left unsprayed as controls. Spraying was begun on 22nd September, but, owing to a breakdown of the machine, was not completed until the 23rd. All drops were cleared away on the 23rd and the subsequent drops were collected and counted on 12th October. The fruits were picked from one sprayed and one control tree in each block on that date. The drops under the remaining trees were collected and counted on 1st November and the fruits were picked from another sprayed and another control tree in each block. The drops under the remaining trees in each block were collected on the 10th November, and the fruits were picked. On each occasion the fruits dropped or knocked off during picking were collected and counted separately.

The weight of fruit picked from each tree was determined, and the number picked was estimated by weighing a random sample of 100 fruits from each tree. The initial number of fruits present on each tree on 23rd September was estimated by summing the number of drops and the estimated number picked.

TABLE III.

EFFECT OF A LATE NAA SPRAY AND OF DELAY IN PICKING UPON ACCUMULATED PERCENTAGE DROP, AND CROP, 1949.

Treatment.	No. of trees.	Date picked.	Spray 22-23rd Sept.	Percentage dropped.* up to 12 Oct.	up to 1 Nov.	up to 10 Nov.	during picking.	Percentage picked.*	Mean crop per tree, lb.	Mean weight per 100 fruits, lb.
1	10	12th	NAA	2	—	—	5	93	444	21·4
2	10	Oct.	nil	3	—	—	5	92	437	20·1
3	10	1st	NAA	2	20	—	3	77	415	23·2
4	10	Nov.	nil	3	21	—	3	76	462	22·2
5	10	10th	NAA	2	19	30	6	64	356	24·9
6	10	Nov.	nil	4	22	32	5	63	330	24·4
		12th Oct.	Mean					92	441	20·8
		1st Nov.	Mean					77	438	22·7
		10th Nov.	Mean					63	343	24·6
		General mean						77	407	22·7
Sig. diff. (P = 0·05) between means								*4*	*49*	*2·1*

* Based on estimated total numbers of fruits on trees on 23rd September.

The percentages dropped and picked, worked out on this basis, are shown in Table III. The mean weight of crop per tree, and the mean weight of the sample 100 fruits are given in the last two columns of the same table. It is evident that the percentage picked differed widely and significantly on the three occasions. The mean weight per 100 fruits, however, progressively increased. This growth in fruit weight compensated to some extent for loss in numbers and the weight of crop per tree was much the same on the first two occasions, though significantly less on the third. In no instance did the NAA spray have any important or significant effect.

1950 Trial.

This trial was carried out on trees in the same plantation as those in 1949, but was on a smaller scale. There were five blocks each consisting of four trees ; two trees in each were sprayed with NAA in sunny warm weather on 21st September, the other two were unsprayed. All drops were cleared away on the 22nd September. On 9th October the drops under each tree were collected and counted and the fruits were picked from one sprayed and one unsprayed tree in each block. The final collection of drops and picking of fruits was done on 24th October. Drops during picking were collected separately on both occasions. As the trees were few and the crops rather light, it was possible to count the picked fruits as well as the drops and to sort them into sound and unsound.

TABLE IV.

EFFECT OF A LATE NAA SPRAY AND OF DELAY IN PICKING UPON ACCUMULATED PERCENTAGE DROP, AND CROP, 1950.

Treatment.	No. of trees.	Date picked.	Spray 21st Sept.	Percentage dropped.* up to 9 Oct.	up to 24 Oct.	during picking.	Percentage picked.* total.	sound.	Mean crop per tree, lb.	Mean weight per 100 fruits, lb.
1	5	9th	NAA	7	—	3	90	75	208	23·3
2	5	Oct.	nil	9	—	4	87	73	191	23·6
3	5	24th	NAA	7	28	5	68	60	202	31·8
4	5	Oct.	nil	9	34	4	62	56	192	30·6
		9th Oct	Mean	8	—	3	89	74	199	23·5
		24th Oct.	Mean	8	31	4	65	58	197	31·2
		General mean					77	66	198	27·3
Sig. diff. (P. = 0·05) between means							*9*	*8*	*n.s.*	*2·7*

* Based on total number of fruits on trees on 22nd September.

The results are shown in Table IV. Here the percentages are based on the total number of fruits present on the trees on 22nd September, whether or not they were subsequently found to be sound. Both the total percentages picked and the percentages picked as sound fruits are shown, but in the case of the drops only the total percentages are given since here many of the unsound may have become so as a result of infection with Brown Rot after leaving the trees. The values for mean crop per tree and mean weight per 100 fruits are based on sound fruits only. In no case was there any significant difference between the values for sprayed and unsprayed trees. The percentage picked was considerably reduced by postponement of picking, but the weight of crop remained much the same owing to a considerable increase in weight per 100 fruits during the interval. In general the crop was rather light, only some five bushels per tree.

Discussion.

The results of the trials described in this report provide further evidence that sprays containing NAA have little, if any, effect on abscission of fruits of Bramley's Seedling. It is possible that the ineffectiveness of the sprays applied in May and June may have been due in part to the NAA having been mixed with the lime-sulphur or mercurated lead arsenate. In practice, however, the chief value of using NAA at such a time lies in the possibility of adding it to some routine spray ; its effect would have to be very considerable to justify its application as a separate spray.

The increase in individual fruit weight, when picking was delayed, was surprisingly large, and compensated to a considerable extent for the reduction in fruit numbers. Increase in size, however, is not always an advantage.

Summary.

1. Addition of NAA to lime-sulphur and mercurated lead arsenate sprays, applied in May and June, had no appreciable effect on subsequent fruit drop in Bramley's Seedling.

2. Postponement of picking for periods up to a month resulted in considerable fruit drop, which was not controlled by a spray of NAA, but was largely compensated for by an increase in individual fruit weight.

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USE OF SPRAYS TO CONTROL FRUIT DROP

IX. FURTHER TRIALS OF THE EFFECTS OF DELAY IN PICKING AND OF NAA SPRAYS ON FRUIT DROP IN COX'S ORANGE PIPPIN

By M. C. VYVYAN and G. F. TROWELL

It was found in 1948 (Vyvyan, West and Barlow, 1949), that a week's delay in picking resulted in a heavy fruit drop in Cox's Orange Pippin, and a fortnight's delay in the loss of about half the crop. A spray of α-naphthalene-acetic acid (NAA) at 10 p.p.m., applied some three weeks before the normal picking date, largely controlled the drop. The quality of the fruit after a period in cool store was highest in those picked last. As there is evidence that seasonal conditions may influence both the severity of fruit drop and the effectiveness of NAA sprays, further field trials of the same type were carried out in 1949 and 1950 and are described in this report.

The 1949 trial.

Sixty mature trees, arranged in 10 blocks of six, were used. Three in each block were sprayed with a solution of 10 p.p.m. NAA, at the rate of about 6 gallons per tree, on 23rd September, 1949 ; the other three were left unsprayed as controls. All drops already under the trees were removed on this date. The fruits from one sprayed and one unsprayed tree in each block were picked on 4th October, those from a similar pair of trees in each block on 19th October, those from the remaining trees on 3rd November. The intervals between successive pickings were thus longer than in 1948—a fortnight instead of a week. On each occasion the drops under every tree were collected into boxes before the trees were picked. These drops, and those that dropped or were knocked off during picking, were sorted into three categories, viz. ' sound ' fruits, those affected by Codling and those by Brown Rot : those in each class were counted and the weight of the sound fruit determined. On the first two occasions the picked fruits were similarly sorted, counted and weighed, but on the final occasion (3rd November) many fruits, that were otherwise sound, showed bird damage, much of it very severe ; these fruits were constituted into a fourth category ' bird damage ' and weights were based on sound undamaged fruits alone.

In the 1948 trial it was found that the unsound fruits formed about the same proportion of the total, approximately 14 per cent, under each treatment ; they were, therefore, ignored, and all percentages were based on sound fruits alone. In 1949, however, the proportion of the total fruits (dropped and picked) recorded as ' unsound ' progressively increased from one picking date till the next. This was mainly due to the spread of Brown Rot amongst the drops and on the trees. Only about 3 per cent suffered from this up to the first picking (4th October), and over 25 per cent at the third (3rd November). The percentage affected by Codling fell slightly from about 20 to 14 per cent during the same period, due probably to some infested fruits being missed on the last occasion owing to their symptoms being masked by severe Brown Rot.

Thus the numbers recorded as sound were influenced by the postponement of picking and cannot be regarded as an index of the number of sound fruit present at the start of the trial. All percentages were, therefore, calculated on the basis of total number of fruits (sound and unsound) as these values will not have been influenced by the treatments.

The main results of the 1949 trial are shown in Table I. The percentages dropped up to successive dates have not been included ; they can, however, be estimated. For example, in the case of trees picked on the 4th October, the values for total percentages picked from sprayed and unsprayed trees were 91 and 85 per cent respectively, the remainders, 9 and 15 per cent, represent the drops—including those during picking. The incidence of Codling damage amongst picked fruits fell from 13 to 14 per cent in those picked first to some 3 to 5 per cent in those picked last ; this was mainly due to the tendency for Codling fruits to fall before the others. The incidence of Brown Rot rose from 0 to 8 per cent, showing that the increase in the total percentage of Brown Rot was not solely due to infection of the fruits on the ground after they had dropped.

In general, the mean differences between the values for sprayed and unsprayed were just significant, whether ' total ' picked or those picked ' sound ' are considered. In both cases the percentages for the three picking dates are widely and very significantly different. The mean crops in pounds per tree were rather light and very variable. Statistical analysis of these values was not, therefore, considered worth while.

The 1950 trial.

Ten blocks, each consisting of four mature trees, were used in this trial. Two trees in each block were sprayed with 10 p.p.m. NAA on 6th September, the other two were left unsprayed. The weather on the 6th was dull and heavy rain fell during the following night ; this may have reduced the effectiveness of the spray. The drops already on the ground were cleared away on the 7th. The fruits were picked from one sprayed and one control tree in each block on 25th September and from the remaining trees on 10th October. It will be noted that 1950 was an early season ; the 25th September was the date when all the fruits would have been picked on this plot had no trial been in progress. The usual collections, counts and weighings of drops and picked fruits were carried out, but in this trial the unsound fruits formed only a small proportion of the total, less than 10 per cent, and were not subdivided into ' Codling ' and ' Brown Rot '. The percentages were worked out on the basis of the total numbers of sound and unsound fruits, dropped or picked from each tree, and are shown in Table II.

The drop up to the 25th was light, but was very significantly less from sprayed than from unsprayed trees. By the 10th October it amounted to nearly a quarter of the crop in the case of the unsprayed trees, but was only 11·1 per cent from the sprayed. The percentage picked was significantly greater in sprayed trees and significantly less in those picked late. The actual crops, expressed as pounds per tree, were very variable owing to large differences in initial numbers of fruits per tree, and, on this account, the differences between mean values for crop per tree for the various treatments are not significant.

Discussion.

In general, the results of these two trials confirm those found in 1948. Postponement of picking increased the drop and an NAA spray reduced it. In 1949 and 1950, however, both the severity of the drop and the effectiveness of the spray were less than in 1948. Less control was required and less was obtained. The percentages for 1949 and 1950, shown in Tables I and II, are based on total

Table I.

Effect of an NAA spray and of delay in picking upon the percentage of fruits picked and upon weight of crop per tree and weight per 100 fruits of Cox's Orange Pippin, 1949.

Date of picking.	Spray (23rd Sept.).	Percentage picked.*					Mean crop per tree, lb.	Mean weight per 100 fruits, lb.
		Sound.	Bird damage.	Codling.	Brown Rot.	Total.		
4th October	NAA	78		13	0	91	104	16·5
	nil	71		14	0	85	91	17·8
19th October	NAA	67		11	1	79	107	19·2
	nil	59		9	1	69	74	18·4
3rd November	NAA	21	27	5	8	61	36	14·6
	nil	18	27	3	8	56	33	13·2
Mean	NAA	64				77		
Mean	nil	58				70		
Sig. diff. ($P = 0{\cdot}05$)		6				7		
4th October	Mean	74				88		
19th October	Mean	63				74		
3rd November	Mean	47				59		
Sig. diff. ($P = 0{\cdot}05$)		7				7		

* Based on total numbers of fruits on trees on 23rd September.

numbers of fruit, sound and unsound, and are not strictly comparable to the values presented in the report on the 1948 trial (Vyvyan, West and Barlow, 1949) as those were based on sound fruits only. If calculated upon a common basis, however, the difference between the severity of drop in 1948 and that in 1949 and 1950 would have appeared even greater, the ratio of unsound to sound being greater in the dropped than in the picked fruits in each of the latter years.

TABLE II.

EFFECT OF AN NAA SPRAY AND OF DELAY IN PICKING, UPON PERCENTAGES OF FRUITS DROPPED AND PICKED, AND UPON WEIGHT OF CROP PER TREE AND WEIGHT PER 100 FRUITS OF COX'S ORANGE PIPPIN, 1950.

Date of picking.	Spray* (6th Sept.).	Percentage dropped.†			Percentage picked.†		Mean crop per tree, lb.	Mean weight per 100 fruits, lb.
		to 25th Sept.	to 10th Oct.	during picking.	Sound.	Unsound.		
25th September	NAA	5·5		2·2	86·0	6·3	232	17·6
	nil	7·5		2·7	84·4	5·4	201	16·7
10th October	NAA	4·2	11·1	3·6	80·5	4·8	236	17·4
	nil	7·9	23·1	3·5	70·2	3·2	181	16·8
Mean	NAA	4·8	11·1		88·8		234	
Mean	nil	7·7	23·1		81·6		191	
25th September	Mean				91·0		217	
10th October	Mean				79·3		208	
Sig. diff. ($P = 0·01$)		*1·9*	*11·6*		*6·0*		*n.s.*	

* Followed by rain on the succeeding night.

† Based on total numbers of fruits on trees on 7th September.

Summary.

Postponement of picking for two to four weeks in 1949 and for two weeks in 1950 resulted in considerable fruit drop in Cox's Orange Pippin.

Sprays of NAA at 10 p.p.m., applied some three weeks before the normal picking date, considerably reduced the drop. Neither the severity of the drop nor the effectiveness of the spray was as great as in 1948.

No significant trend in the mean weight per fruit was detected in either experiment.

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A METHOD OF ESTIMATING SCORCH ON LEAVES

By F. W. M. LLEWELYN* and M. ALLEN

Introduction.

The effects of spray materials in damaging plants has long been noticed by all concerned with their application. It is only in recent years that the study of these effects has been taken up intensively ; however, the discovery of selective herbicides has led to many investigations on the complete kill of plants, and the subject has been reviewed recently by Blackman, Templeman and Halliday (1951). The small size of weeds and their ease of cultivation facilitates experiments on large numbers of plants, and the proportion which succumbs to any treatment can be recorded. Hence it has been possible by varying the amounts of toxicant used, to establish doses which bring about a given response in the population of plants tested, and to compare toxicants or plant reactions by means of a dosage-response curve (Fogg, 1948 ; Blackman, Holly and Roberts, 1949). It is not practicable, however, to apply this method to plantations of fruit, and for such crops it would be advantageous to be able to assess the damage done to individual leaves by the application of a toxic spray. This paper describes attempts to achieve this object.

Method.

Raspberry leaves sprayed with ammonium thiocyanate solutions become discoloured after a day. This prompted an attempt to measure the loss of chlorophyll caused by the spray and to use it as an index of damage. However, it was found that although signs of damage were apparent one day after spraying, no significant change of chlorophyll content could be detected in the same period, and only later did the chlorophyll content fall, taking a week to attain its final value. Although this method could be used, the extraction procedure is lengthy, and a more expeditious method based on a quicker response was sought. To this end, the use of the water content was considered, and the following argument developed :

When a leaf is scorched, the damaged part of the leaf loses water, and the ratio of the fresh weight to the oven dry weight of the leaf falls ; the extent of this fall will depend upon the amount of tissue scorched. Thus, if x grams of oven dried healthy tissue have a fresh wt./dry wt. ratio of a, the fresh weight of the x grams is ax grams, and if y grams of oven dried dead tissue have a fresh wt./dry wt. ratio of b, then the fresh weight of the y grams is by grams. The fresh weight of the complete leaf is $ax + by$ grams, and the weight of the complete oven dried leaf is $x+y$ grams. The fresh wt./dry wt. ratio of the whole leaf is : $\frac{ax+by}{x+y} = r$.

It is required to find c, the extent of the damage, in terms of r, a and b, where $c = \frac{y}{x+y}$.

Now $r = \frac{ax+by}{x+y}$, whence $x = \frac{(r-b)y}{a-r}$. Substituting for x in $c = \frac{y}{x+y}$ we obtain the relationship

$$c = \frac{a-r}{a-b}.$$

Thus, provided the fresh wt./dry wt. ratio of undamaged leaves and completely damaged leaves is known, then the proportion by weight of a partially damaged leaf that is affected can be calculated.

The use of this formula will give reliable results only if r, a and b are all determined under the same conditions. Thus, if it is desired to determine the amount of damage caused by a particular solution to the leaves of a plant, three treatments are allotted at random to the leaves ; one, a blank giving the value of a ; the second, the experimental solution, giving the value of r ; and the third, a treatment with a solution of the same substance of such a concentration that it will kill the whole leaf, giving the value of b. For a given amount of damage in the leaf, the assessment of the damage should be independent of time, even though the loss of water from the damaged areas varies with time. The results of an experiment designed to test the validity of this assumption, and which show that the amount of damage did not vary significantly after two days, were as follows :

Time in days between spraying and measuring percentage of leaf damaged	1	2	4	6	8
Percentage of leaf damaged by 0·4% ammonium thiocyanate	8·10	15·9	30·0	29·3	27·6

Significant difference = 16·4.

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It will be clear from Fig. 1 that after two days 90% of the maximum water loss had occurred.

These results led to a technique which is best described by reference to an actual experiment, the object of which was to determine the damage caused by various concentrations of ammonium thiocyanate sprayed on to the upper or lower surfaces of raspberry leaves. Twenty potted Malling Enterprise raspberry plants were divided into 4 blocks of 5 ; 4 leaves, occupying the same positions on each cane, were selected for treatment, the lateral leaflets only being used. On each leaf, one leaflet was used for one of the two controls (blank, or completely killed), and the other leaflet for one of the test solutions. Thus, on any one cane, the following treatments were applied :

Test solution to the upper surface of 2 leaflets.
,, ,, ,, ,, lower ,, ,, 2 ,,
Killing ,, ,, ,, upper ,, ,, 1 ,,
,, ,, ,, ,, lower ,, ,, 1 ,, } controls.
No ,, ,, 2 leaflets.

Five test solutions were used in each block, only one being applied per cane. The controls were assigned at random to the leaf positions, subject to the restriction that within the whole population equal numbers of each control were allotted to each leaf position. Applications to the upper and lower surfaces were similarly randomized.

Each leaflet other than the blank controls was sprayed to complete wetting with a hand atomizer. The five test solutions all contained 0·1% Agral LN. as wetting agent, and 0·3%, 0·4%, 0·5%, 0·6% or 1·0% ammonium thiocyanate ; a solution of 2·0% ammonium thiocyanate and 0·1% Agral LN. was used as the ' complete killing ' solution for the second controls.

The plants were kept under glass for 48 hours after spraying. The leaflets were then picked and weighed in rotation, placed in an oven at 50° C. and allowed to dry overnight. On the following morning the dry weights of the leaflets were taken and the fresh to dry weight ratio for each leaflet calculated (Table I).

The concentrations used in this experiment were selected as a result of previous experience of spraying the lower surfaces of raspberry leaves, from which it was known that 2·0% ammonium thiocyanate was sufficient to kill the entire leaflet. As 2·0% thiocyanate applied to the upper surface did not kill the entire leaflet, the completely killed controls set up for the lower surface section of the experiment had to be used as controls for the upper surface also, and the 2·0% solution on the upper surface regarded as an extra treatment. The design of the experiment was such that this dual use of the completely killed controls was statistically legitimate, and, since the leaflets were completely killed, it was immaterial whether they had been killed from the upper or lower surface.

TABLE I

MEAN FRESH WT./DRY WT. RATIOS AND PERCENTAGE DAMAGE OF RASPBERRY LEAVES SPRAYED WITH VARIOUS CONCENTRATIONS OF AMMONIUM THIOCYANATE.

		Undamaged control.	Concentration of ammonium thiocyanate in spray solution.						Completely killed control.
			0·3%	0·4%	0·5%	0·6%	1·0%	2·0%	
Upper surface.	Mean fresh weight/dry weight ratio.	2·830	2·601	2·688	2·508	2·508	2·310	2·025	1·395
	Percentage damage.	0	16	10	23	23	36	56	100
Lower surface.	Mean fresh weight/dry weight ratio.	2·834	2·360	2·108	1·800	1·790	1·556	—	1·395
	Percentage damage.	0	33	50	72	73	89	—	100

From the mean values of the ratios obtained, the percentage damage was calculated for each treatment, and two straight lines, which relate the probit of this damage to the logarithm of the concentration, were fitted (Fig. 2). Statistical analysis, using the method described by Fogg (1948), showed no significant departure from linearity, and also no significant difference between blocks.

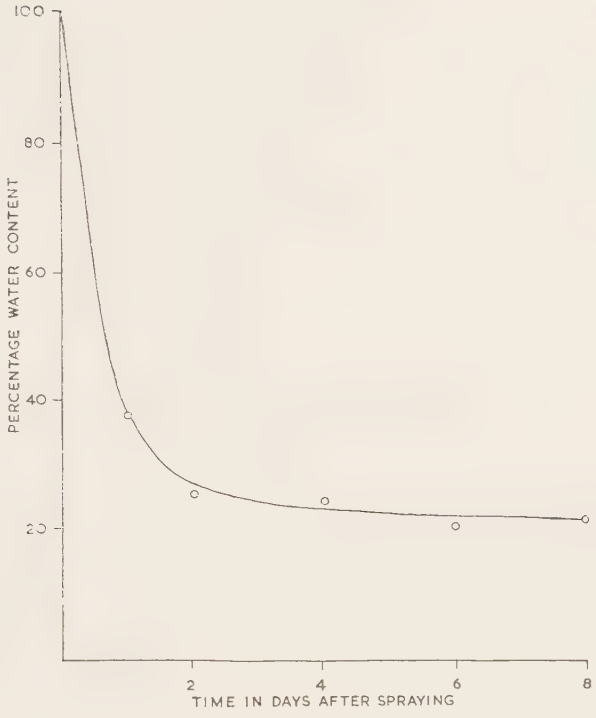

FIG. 1.

The effect of time on the drying-out of damaged leaf tissue as measured by the water content per unit dry weight of killed leaf expressed as a percentage of the water content of a healthy leaf.

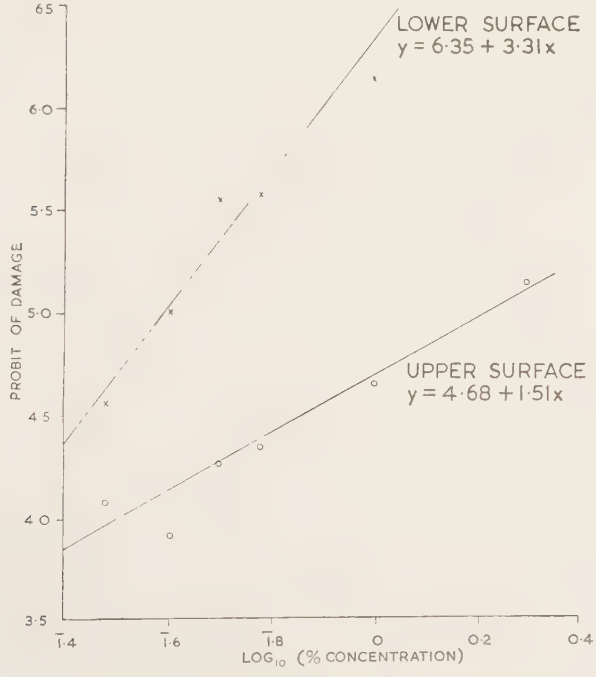

FIG. 2.

The effect of concentration of ammonium thiocyanate on the damage caused to raspberry leaves.

Discussion.

These results show that the technique described above gives a simple method of estimating the damage done to individual leaves in a controlled experiment, where adequate standards can be set up. Later attempts to measure the damage done to leaves of raspberry and Cox's Orange Pippin apple by ammonium thiocyanate or copper sulphate failed for all cases except the ammonium thiocyanate on raspberry leaves, because the unsprayed controls eventually showed signs of damage due, presumably, to translocation of toxic materials from the completely killed leaves. So far as could be judged, spread of the damage only occurred if the treated leaf was completely killed, whether by copper sulphate or ammonium thiocyanate ; but thiocyanate damage on raspberry leaves did not spread, however strong the solution applied.

In the case of poisons which are freely translocated, the problem might be overcome by taking advantage of the peculiarities of the vascular system so that an untreated leaf has no direct vascular connection with a heavily damaged leaf, but this would severely restrict the randomization of treatments. It may later be found permissible to assume the straight line relation between probit damage and log. concentration, thereby allowing the ' completely killing ' solutions to be omitted from the experiment, an estimate being made of the limiting fresh wt./dry wt. ratio when all the leaf is killed from the results of the treatments applied. Further work is in hand on these aspects.

Summary.

A method of measuring scorch on raspberry leaves due to ammonium thiocyanate sprays is described ; it involves measurement of the fresh weight and oven dry weight of treated leaves and suitable controls. A linear relation between the probit of the percentage damage and the logarithm of the concentration of thiocyanate applied is shown to exist when the spray is applied to the upper or lower surface of the leaf. Extensions and limitations of the method are discussed.

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THE EFFECT OF WETTER CONCENTRATION ON AMMONIUM THIOCYANATE DAMAGE TO RASPBERRY LEAVES, AND ON THE VOLUME OF SPRAY REQUIRED TO ACHIEVE COMPLETE WETTING

By F. W. M. LLEWELYN* and M. ALLEN

Introduction.

Following the development of a technique for estimating damage on raspberry leaves (Llewelyn and Allen, 1952), it was decided to examine by this method the effect of differing wetter concentrations on the damage produced in the leaf and also their effect on the volume of spray required before complete wetting was achieved.

Experimental details.

The sprays were applied by means of a glass hand atomizer, calibrated in ml., to the hairy undersurfaces of leaves of potted plants of Malling Enterprise raspberries until the whole surface had turned a deep green colour, indicating that the air between the hairs had been displaced. ' Run-off ' of spray had always begun before this stage was reached.

A concentration of 0·4% ammonium thiocyanate was selected for the test solutions, as experience had shown that, in the presence of 0·1% Agral LN., this would give 50% damage. This solution was made up in the following concentrations of Agral LN. : 0·025%, 0·05%, 0·10%, and 0·20% w/v, representing a wider range than is generally used in the field. Half of the leaflets selected for controls were sprayed with 2·0% ammonium thiocyanate in 0·1% Agral LN. to cause ' total damage ' ; the remainder, ' undamaged ' controls, were not treated.

One new cane on each of eight plants was used, and one side leaflet of each of the 4th-11th leaves (counting from the apex) was treated with the test solution, the other side leaflet serving as a control (either undamaged or totally damaged). Each test solution was applied twice to each cane, in such a way that each leaf position throughout the experiment received an equal number of all treatments. Controls were so allotted that the two similar treatments on a cane had dissimilar controls applied to the other leaflet of their leaves.

The plants were sprayed in a greenhouse on a warm September morning, and the volume of spray required to wet each leaflet thoroughly was noted. After two days, each leaflet was picked and its fresh weight obtained. The leaflets were then placed in an oven overnight at 50° C., and their dry weights taken the following morning.

Results.

Statistical analysis of the volume of spray used per unit dry weight in mls./gm. showed the plants to differ significantly in the volume required to achieve complete wetting ($P=0.05$).

The plant means were :

Plant number	2	7	6	3	8	4	5	1
Mean volume per unit dry wt. ..	2·70	2·83	3·19	3·30	3·41	3·45	4·34	4·65

Significant difference = 1·16

The concentration of wetter had a large effect upon the volume of spray required to achieve complete wetting ($P=0.01$), the mean volumes for the various concentrations being :

Concentration of Agral LN. ..	0·20%	0·10%	0·05%	0·025%
Mean volume per unit dry wt. ..	2·04	2·89	3·65	5·36

Significant difference = 0·82

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There was no significant difference between the volumes per unit dry weight required to obtain full wetting at the various leaf positions.

Analysis on the fresh wt./dry wt. ratios showed that neither plants nor positions of leaves differed significantly, although plants came near to significance ($P=0{\cdot}05$).

The percentage of a leaflet damaged was calculated from the formula $c = \frac{a-r}{a-b} \times 100$, where
c is the required percentage,
a is the fresh wt./dry wt. ratio of an undamaged leaflet,
r is the fresh wt./dry wt. ratio of a partially damaged leaflet, and
b is the fresh wt./dry wt. ratio of a totally damaged leaflet.

The analysis of the data for the percentage of leaf damaged showed that, in contrast to its effect on the volume of spray used, the concentration of wetter had no significant effect, the means being :

Concentration of Agral LN. ..	0·20%	0·10%	0·05%	0·025%
Mean percentage damage	42·5	42·5	48·4	49·5

Significant difference = 10·7

The percentage damage done at each leaf position showed significant differences ($P=0{\cdot}05$), the means being :

Position of leaf counting down from the apex	11	9	8	10	6	7	5	4
Mean percentage damage.. ..	36·4	36·8	40·0	41·6	44·6	48·5	56·3	61·7

Significant difference = 16·8

The damage done to each plant showed significant difference at $P=0{\cdot}01$, the means being :

Plant number	5	8	4	2	7	1	6	3
Mean percentage damage.. ..	31·4	32·8	36·9	43·7	44·9	54·9	57·5	64·0

Significant difference=16·8

Discussion.

The results of this experiment indicate that the volume of spray liquid required to be applied per unit dry weight of leaf to achieve complete wetting fell with rising concentrations of wetter. This volume can be regarded as one measure of the efficacy of the wetting solution, and gives a value pertinent to field investigations, but many variable factors, not easily standardized, enter into the final result.

A drop of spray, as it leaves the nozzle of the atomizer, has a comparatively new surface which is not in equilibrium with the bulk of the drop ; consequently the surface tension of the drop is greater than its equilibrium value. With time, the molecules of the wetter accumulate at the surface, coming from the interior of the drop, and the surface tension decreases ; the rate at which this falls is a function of the concentration of the wetter in the bulk of the liquid (cf. Addison, 1945). Hence the volume of spray required to give complete wetting will be affected by the age of the drops, their initial surface tension (which is controlled by the rate of formation and size of the drop), the concentration of wetter, and the accuracy of directing the spray at the leaf. The adhesion of spray droplets on impact with solid surfaces is discussed in detail by Moillet and Collie (1951), the discussion above serving only to show how complex are the factors involved in applying a spray to a plant.

The striking constancy of the damage done, even when the wetter concentration is increased eight-fold, is best explained as a property of the hairy surface ; the likelihood of changes in amount retained being exactly balanced by an interaction between the wetter and the ammonium thiocyanate is so remote that the results can be held to demonstrate the absence of such interaction. It may therefore be deduced that changes in the concentration of wetter have no effect on the volume of spray retained by a hairy leaf ; further work is in progress to confirm this preliminary deduction.

Summary.

Individual leaflets of potted raspberry plants were sprayed on their lower surfaces with an ammonium thiocyanate solution containing various concentrations of a wetting agent. The volume of spray per unit dry weight of leaf needed to cause complete wetting of the leaf decreased with increasing wetter concentration, but the proportion of leaflet damaged was unaffected. It is assumed that

there is no interaction between Agral LN. and ammonium thiocyanate on raspberry leaves, and that, for densely hairy leaves, over the range of concentrations tested, the volume of spray retained by the leaf is substantially unaffected by the wetter concentration.

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BIOCHEMISTRY

A QUANTITATIVE METHOD OF FLAME SPECTROGRAPHIC ANALYSIS

By F. H. VANSTONE

Introduction.

The quantitative modification of the flame spectrographic method already described (Vanstone and Philcox, 1950) has now been in operation for some six months, mainly for the analysis of samples, each consisting of a single apple leaf ; this preliminary report may be of interest to workers in the same field.

The apparatus itself has not been modified apart from minor geometric changes designed to improve its performance ; but the treatment of the samples is somewhat different from that originally described. They are now ashed and each is mixed with a standard amount of a powder containing suitable amounts of elements chosen to act as internal standards. The mixture is then introduced into a cartridge and burnt, as in the earlier method. The line density of each plant constituent is compared with that of the standard element. Three advantages are obtained in this way :

(*a*) Variability due to changes in flame temperature is eliminated because the element to be determined, and the internal standard, are heated in the same part of the same flame.

(*b*) Variability due to difference in sensitivity between one part of a photographic plate and another is reduced, but not eliminated, if the internal standard is so chosen that it has a comparison line close to that of the element to be determined.

(*c*) The effects of the suppression of the lines of elements, such as calcium, by silica or phosphorus, can be compensated for by using as internal standard an element, such as barium, the lines of which are suppressed in a similar way to those of calcium.

Internal standard powder.

Ideally the internal standard line for each element determined should be provided by an element not present in the sample. A rapid, but fairly exhaustive, survey failed to reveal elements, suitable in other ways, for the determination of calcium, strontium, manganese, iron, potassium, copper and magnesium, that were absent from plant material ; but the powder now used contains lead, cadmium, and barium in amounts very considerably higher than is normally found in plant material. These three elements are applied in solution to a pure cellulose powder and the mixture dried, ground and sieved through bolting silk. The composition of the mixture is as follows :

Cellulose powder	56·9%
Ammonium chloride	19·0%
Barium chloride	15·8%
Cadmium sulphate	2·9%
Lead acetate	5·4%

Treatment of samples.

The samples (usually 50 mg. leaf powder) are weighed into silica micro-crucibles, 20 of which are held in a silica carrier. They are ashed over-night at 420-440° C. and allowed to cool in a desiccator ; 19 mg. of the above mixture is then added to each crucible and mixed with the plant ash with the aid of a small platinum spade. Since this operation is carried out in the crucible, there is little danger either of loss or contamination of the sample. The mixture is transferred directly from the crucible to the pressing mould, the cellophane tube filled and the samples are burned, as described in the previous paper.

Table I shows the element and internal standard lines used for each element studied and its range of concentration when 50 mg. of sample is used. This is not the full range that can be catered for, but merely the range which has so far been studied and which was considered to be adequate for a particular series of samples to be analysed. The actual lower limit of concentration which can be determined accurately is appreciably lower than that shown in the table for all the elements shown except copper. A sample weight of 15-20 mg. would certainly give as accurate results as 50 mg. for calcium, manganese, iron, potassium and magnesium, but to estimate 3 p.p.m. of copper accurately it

s necessary to use 50 mg. Since the copper content of the series of samples to be analysed was unpredictable and since in most cases only one aliquot of approximately 50 mg. of each sample was available, it was decided to use this latter weight. As will be seen later, it may prove advantageous to determine copper on a 50 mg. sample and the other elements on a 15-20 mg. sample.

Table I.

Element and line used as internal standard for the determination of certain plant constituents.

Element line.		Internal standard line.	Range of concentration studied.
Ca	4454·78 Å.U.	Ba 4554·042 Å.U.	0·2-3·2 per cent
Mn	4030·755	Pb 4057·82	10-320 p.p.m.
Fe	3719·935	Pb 3683·471	10-500 p.p.m.
K	3447·701	Cd 3261·057	0·25-4 per cent
Cu	3247·54	Cd 3261·057	3-50 p.p.m.
	3273·962		
Mg	2852·129	Pb 2833·069	0·05-0·8 per cent

Cd 3261·057 is not very suitable as an internal standard for K 3447·701 as the gamma of the plate to the two wavelengths is quite different and the two lines are 1 cm. apart on the plate. Co 3453·505 was used for a time until it was found to be suppressed seriously by values of potassium above 2 per cent.

When time allows, the search for a more suitable internal standard for potassium will be resumed.

Suppression of lines of certain elements by presence of other elements.

The effect of each element, within the range of concentration of Table I, and also of silica and phosphate, on the other elements has been investigated. The elements potassium, copper, cadmium and lead have been found to be independent of all other elements over their full range.

The effect of increasing concentration of silica on the apparent amount of iron, manganese and magnesium was as follows :

Table II.

Per cent silica.	0	1·2	2·4
Iron	109 p.p.m.	67 p.p.m.	63 p.p.m.
Manganese ..	56 ,,	43 ,,	41 ,,
Magnesium ..	0·55 per cent	0·16 per cent	0·13 per cent

From the data available at the moment the silica content is normally above 1 per cent, so these latter effects are not very serious.

As potassium is increased from 0·5 to 4 per cent, apparent magnesium is decreased progressively from 0·27 to 0·22 per cent. Both calcium and barium are suppressed seriously by silica, and to a lesser extent by phosphate, but since the order of suppression is similar for both calcium and barium and since barium is the internal standard for calcium this effect is not likely to prove very troublesome.

Compensation for the effect of silica and phosphate.

In view of the effect of silica on so many of the elements in which we are interested and of phosphate on some of them, allowance has to be made for the combined effect. Since in many cases only one aliquot of sample is available, such a determination would have to be made from the flame spectrogram, in which neither silica nor phosphate gives a line. Now lead is unaffected by the silica or phosphate content whilst barium is progressively suppressed. Since the ratio of barium to lead in the internal standard powder is constant and practically independent of the concentration of either in the sample, then it was thought possible that the ratio of the intensities of these two lines in the presence of the sample might give a measure of the combined effect of the silica and phosphate content of the sample. Preliminary indications are that the method will make possible the necessary corrections in the determination of calcium, magnesium, manganese and iron, except perhaps when there is

more than 2 per cent calcium. The background increases rapidly with increase of calcium above this value, but the effects of this can probably be avoided by using a 15-20 mg. sample. This will be tested in due course.

Photometry.

A seven-step neutral wedge, with a step ratio of 3 : 2 is placed immediately in front of the slit. This leads to spectrum lines 7 mm. long and makes possible the production of 16 spectra (eight on each side) on a 10-inch by 4-inch plate when a medium spectrograph is used. Measurements are made on three steps of each line within the density range 0·15-0·8. The density values are plotted against the logarithm of the percentage of light transmitted by the corresponding steps. The element graph and the internal standard graph are both slightly curved. Their ' separation ' (i.e. their distance apart) at a given density gives the ratio of the intensities of the two wavelengths. A density of 0·3 is chosen because this gives the most reliable ratio. Background correction is made where necessary using the subtractive logarithm tables of Mitchell, Scott and Farmer (1944). Lead lines, alone of those so far examined, are not increased in density by increasing density of background ; no explanation can yet be offered of this unexpected fact. Clearly no correction for background should be made for lead lines. The concentration of the element is obtained from the standard curves, in which the ' separation ' of the element from its internal standard is plotted against the logarithm of the concentration of the element.

Production of standard curves.

60 mg. of cellulose powder is weighed out into each of 15 silica micro-crucibles, held in the silica carrier. The powder is pressed lightly with a glass rod and 0·024 ml. of each of the following two solutions is applied separately by means of a micro-pipette to the powder in each crucible.

The element under consideration, say X, is, of course, omitted from these solutions.

Solution I.

	g.	
K_2SO_4	4·5	to 100 ml.
H_3PO_4	0·43	
$MgSO_4\ 7H_2O$	6·0	
$Na_2B_4O_7\ 10H_2O$	0·1	
$FeSO_4\ 4H_2O$	0·04	
$CuSO_4\ 5H_2O$	0·008	

Solution II.

$CaCO_3$ 5 g. dissolved slowly in re-distilled HCl and made up to 100 ml. with distilled water.

The crucibles are placed in a desiccator for 30 minutes and then a solution of X is applied to the powder, using the 0·024 ml. pipette. Each concentration of X is applied to each of three crucibles. Normally, the concentration of X is halved at each step, so that with the 15 crucibles a concentration range of 16-fold is obtained. Using the above quantities the solutions are absorbed entirely by the powder and the wall of the crucible is not wetted.

After ashing overnight, 19 mg. of the internal standard powder is added to each crucible and the operations already described for the samples are carried out. From the spectrograms three values of the ' separation ' of X from its internal standard are obtained for each concentration of X. The mean of the three values of the ' separation ' at each concentration, plotted against the logarithm of the concentration, constitutes the standard curve for element X.

Optical System.

The flame is 18 cm. from the slit of a Hilger Medium Quartz spectrograph and an image of the flame is focused on the slit by means of a front surface mirror, placed 39·4 cm. from the slit. This system has been shown to give uniform illumination over the length of slit used.

Plate and development.

Ilford chromatic plates are developed in I.D.2 at 68° F. for six minutes.

Reproducibility.

The standard deviation for 16 determinations, using apple leaf powder as the sample, were as follows :

Calcium	1·6%
Manganese	1·5%
Iron	5·0%
Potassium	3·2%
Copper	4·8%
Magnesium	5·6%

Comparison with chemical methods has thus far been on a very limited scale, but no serious discrepancies have yet been revealed.

A more detailed description of the method and its application will be published elsewhere.

Summary.

A quantitative modification of a previously described flame method of spectrography is described. 50 mg. or less of the plant material is ashed and mixed with an internal standard powder before burning as in the previous method. There is serious suppression of the lines of certain elements by the presence of other elements. This is compensated for by choosing as internal standard an element that is affected in the same way as the element to be determined. The method has so far been applied to potassium, calcium, magnesium, iron, manganese and copper.

References

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Mitchell, R. L., Scott, R. O. and Farmer, V. C. (1944). Logarithmic tables for use in quantitative spectrographic analysis II. *Ann. Rep. Macaulay Inst. Soil Res. for 1943-4*, 25-7.

A SENSITIVE METHOD FOR THE DETERMINATION OF MAGNESIUM USING TITAN YELLOW

By A. C. MASON

Introduction.

The method, previously described for the determination of magnesium (Mason, 1950), made use of the red absorption complex formed between magnesium and the dye Titan Yellow in strongly alkaline solution, precipitation of the complex being prevented by using starch solution as a peptizing agent. Defects of the method are poor reproducibility and the small increase in colour intensity over its range. Notwithstanding these criticisms, it remained the most satisfactory method available for small concentrations of magnesium. Young and Gill (1951) have recently described a method which, after adaptation, has been found to be a great improvement. The following points are of interest :

(*a*) Polymerized vinyl alcohol is used as the peptizing agent instead of starch ; it has the advantage of stability when stored in a refrigerator and need not, like starch, be made up fresh each day.

(*b*) The final solution is made strongly alkaline with 40 per cent sodium hydroxide. Since light absorption, due to the dye, depends on the pH, these conditions are the most effective for controlling interference due to excess of the dye.

(*c*) Young and Gill show that the colour due to magnesium is intensified by the presence of copper salts, in addition to the well-known effect due to calcium. The effect of these salts and others is controlled by using a so-called ' compensating ' solution, which is designed to act as a buffer against variations of concentration of these salts in plant material.

(*d*) The concentration of the dye is much lower than usual. This decreases the light absorption due to the excess of dye. As the colour of the dye is orange in alkaline solution, such interference is not eliminated by the light filters employed. Thus precision is improved but the range of the method is somewhat restricted.

Although the points mentioned above greatly improve the precision and sensitivity of the method, one other aspect needs attention. As the dye is unstable in acid solution, the sodium hydroxide must be added *immediately* after the dye; in order to ensure rapid and thorough mixing, mechanical stirring is desirable.

Although Young and Gill give data indicating that their colours obey Beer's Law, our experiments indicate that the relation between optical density of the colours and the quantity of magnesium is a curve passing through the origin, but very closely approaching a straight line within the range of 5 to 25 μg of magnesium. In order to avoid the curved portion of the graph below 5μg, magnesium is included in the compensating solution. In this way, after deducting the blank value, a straight line, passing through the origin, is obtained within the range of 0 to 20 μg of magnesium. The results of many runs, carried out on different days with standard magnesium solutions, show that the slope of the calibration curve varies from run to run. Thus there are still factors not under control, which nevertheless appear to remain constant for the duration of a run. Accordingly, the appropriate calibration line is determined for each run by carrying through a blank and two standard magnesium solutions with each set of unknowns.

Reagents.

Compensating solution.—Calcium chloride, anhydrous, 1·4 g. ; aluminium sulphate, hydrated, 0·37 g. ; manganese sulphate, hydrated, 0·24 g. ; ferrous sulphate, hydrated, 0·25 g. ; tri-sodium phosphate, hydrated, 0·70 g. ; copper sulphate, hydrated, 0·06 g. ; magnesium sulphate, hydrated, 1 ml. of a solution containing 50·67 mg./l. ; concentrated hydrochloric acid, 5 ml. The salts are dissolved in water and made up to 1 litre.

Polyvinyl alcohol.—2 g. vinyl alcohol (polymerized, 25 per cent aqueous gel) dissolved in 100 ml. water. The mixture is heated in a water bath until solution is completed and is then stored in the refrigerator.

Mixed reagent.—Equal volumes of compensating solution, polyvinyl alcohol solution and 1 per cent w/v hydroxylamine hydrochloride solution are mixed just before use.

Titan Yellow.—0·02 per cent solution of the dye in water is prepared freshly each week. The technical grade of Titan Yellow 2 GS has been found satisfactory.

Sodium hydroxide solution.—Two sticks of AnalaR sodium hydroxide, weighing approximately 40 g., are washed quickly with distilled water to remove any carbonate on the surface and then dissolved in water, the volume being made up to 100 ml.

Procedure.

An aliquot of solution, containing not more than 20 μg of magnesium, is transferred to a Pyrex test tube and the volume made up to 5 ml. with water from a graduated pipette ; exactly 3 ml. of mixed reagent is then added. While the solution* is being stirred vigorously by a mechanical stirrer, 1 ml. of Titan Yellow solution is quickly run in, followed immediately by 2 ml. of the sodium hydroxide, making the total volume up to 11 ml. The colour is fully developed in 30 minutes and is stable for at least an hour. It is convenient to carry through runs of 15, i.e. 12 samples, two standards and a blank.

The light absorption is measured in a " Spekker " absorptiometer, using Ilford 604 and neutral filters. The differences in drum reading between the blank and the two standards are determined and plotted against the quantities of magnesium taken. A straight line is drawn through these two points and the origin. The quantity of magnesium in each sample is obtained by referring the appropriate drum difference value to this graph.

High concentrations of neutral salts in the sample solution must be avoided as they cause precipitation of the magnesium-dye complex.

Precision.

In order to give some idea of the precision attained under ordinary conditions, results are quoted for leaf samples, taken at random from a routine batch. Analyses were duplicated in runs, carried out on two consecutive days, two standards and a blank being included in each run. The " Spekker " drum readings for the blank, 10 μg and 20 μg standards respectively were 0·301, 0·408 and 0·520 on the first day, and 0·305, 0·420 and 0·540 on the second day. These figures, when plotted, give two straight lines which pass through the origin, but differ considerably in slope. The appropriate graph for each run was used to calculate the results set out in Table I.

Table I.

Percentage magnesium in dry leaf material. Results of duplicate determinations.

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	0·24	0·19	0·31	0·29	0·26	0·17	0·30	0·27	0·29	0·24	0·02	0·02	0·12	0·11
B	0·22	0·19	0·28	0·25	0·21	0·16	0·29	0·26	0·26	0·21	0·04	0·03	0·15	0·13

Samples 1 to 10 each consisted of 5 mg. of dry matter, which gives a range of 8 to 15 μg for the amount of magnesium estimated. Samples 11 to 14, however, contained estimated quantities of magnesium as low as 1 μg. Since this is near the limit of sensitivity of the method, 10 mg. of dry matter was taken on the second day for these four samples.

Acknowledgement.

The author is indebted to Mrs. R. D. Souter for technical assistance.

Summary.

An improved method is described for estimating small quantities of magnesium by Titan Yellow. The method, which makes use of polyvinyl alcohol and concentrated alkali, is based on that described by Young and Gill.

References

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Young, H. Y., and Gill, R. F. (1951). Determination of magnesium with Thiazole Yellow. *Analyt. Chem.*, **23**, 751-4.

* Cooled to about 10° C. to avoid possible turbidity.

PLANT PATHOLOGY.

A PRELIMINARY REPORT ON STRAINS OF THE APPLE MOSAIC VIRUS

By A. F. POSNETTE and R. CROPLEY

Introduction.

As transmission was first reported in 1825, Apple Mosaic is one of the oldest known virus diseases of plants. Its transmission by grafting has been repeated in most countries where apples are grown, and in England at Long Ashton Research Station (Wallace *et al.*, 1944) and at East Malling Research Station by Prentice in 1946. Usually the conclusion has been drawn that the disease causes little, if any, damage to the crop ; however, the discovery in 1948 of an orchard in Kent where apple mosaic was associated with severe defoliation on trees of Bramley's Seedling led to an investigation of possible strains of the virus. Experiments in 1948, 1949 and 1950 have shown that at least three viruses or strains occur with symptoms of different intensity.

Transmission experiments.

The first experiment to differentiate between types of mosaic was started in 1948 by Dr. I. W. Prentice and continued by the writers in 1949 Three-year-old Bramley's Seedling trees were used as test plants, four being inoculated with bark-grafts taken from a Bramley's Seedling with very severe symptoms of mosaic, four from a similar tree with slight symptoms, and four left uninoculated as controls. In the following summer, there was a marked difference between two of the trees inoculated with ' severe ' mosaic and the other six inoculated trees, the former showing conspicuous chlorotic symptoms, necrosis and leaf fall, and the latter only ' slight ' symptoms. In 1950 and 1951, all the trees inoculated with ' severe ' mosaic showed ' severe ' symptoms, and all the trees with ' slight ' mosaic developed only ' slight ' symptoms. No symptoms appeared on the control trees.

A second experiment was started in 1949 to compare four possibly distinct symptom-types, showing respectively ' slight ' and ' severe ' symptoms on Bramley's Seedling, ' vein-banding ' on Lord Lambourne and ' flecking ' on the same variety. Three varieties were used as indicator plants—Cox's Orange Pippin, Hormead Pearmain and Lord Lambourne—two trees of each for each symptom-type and two as controls, making 30 trees in all.

Inoculations with ' Lambourne vein-banding ' and ' slight Bramley ' types caused identical symptoms in 1950 and in 1951 on each of the test varieties, but these symptoms differed from those caused by the ' Lambourne flecking ' type. None of the plants inoculated with the ' severe Bramley ' type showed symptoms.

From the results of these two experiments it appeared that three viruses or strains were involved (page 129) ; in describing further experiments which supported this conclusion the writer will refer to these viruses as the *severe mosaic*, the *vein-banding*, (= ' Lambourne vein-banding ' and ' slight Bramley '), and the *mild mosaic* (= ' Lambourne flecking ') strains.

An experiment was started in 1950 to discover whether the absence of symptoms from the plants inoculated with severe mosaic in the second experiment was due to failure to transmit the virus or to poor symptom-expression by the varieties used as test plants. Forty maiden Bramley's Seedling trees were graft-inoculated in batches of 10 from either :

(*a*) Bramley's Seedling with severe mosaic, (*b*) Bramley's Seedling with vein-banding, (*c*) symptomless Hormead Pearmain which had been inoculated in the previous year with severe mosaic from Bramley, or (*d*) Hormead Pearmain with vein-banding.

All but one of the 20 trees inoculated with the vein-banding strain developed symptoms in 1951, but none of those with severe mosaic from either Bramley's Seedling or Hormead Pearmain did so.

Rootstocks as test-plants.

This difficulty in transmitting severe mosaic was not encountered in an experiment using as test plants the rootstocks M.I, M.II, M.IV, M.VII, M.IX and M.XVI. Nine plants of each clone were inoculated with severe mosaic and nine with the vein-banding strain, both from the Bramley trees in the first experiment ; the same number of each clone were left as controls. Forty-four of the vein-banding test plants and thirty-three of the severe mosaic test plants developed symptoms the following

Fig. 1.
Symptoms on Bramley's Seedling of the vein-banding strain (above) and the severe mosaic strain (below).

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FIG. 2.
Symptoms on Lord Lambourne of the mild mosaic strain (above) and the vein-banding strain (below).

year, while all the controls remained symptomless. M.VII and M.IX proved to be the best indicators of both types and showed a clear distinction between them. In early summer, the test plants with severe mosaic were brighter yellow than those with the vein-banding strain. M.II was the worst indicator, showing meagre symptoms and often having a two-year incubation period.

Transmission to mature trees.

When the severe mosaic was compared with the mild mosaic strain in graft-transmissions, each to 35 twenty-year-old trees of Cox's Orange Pippin, Worcester Pearmain, Allington Pippin and Newton Wonder on M.IX, 25 trees showed symptoms of severe mosaic, and 15 of the mild strain in the year following inoculation. Each tree, irrespective of variety, developed the symptoms of the virus strain with which it had been inoculated.

Cross-protection experiment.

The ability of a virus to immunize its host against infection by a second virus is regarded as proof that the two viruses are closely related strains. Conversely, the failure to protect is taken as evidence that the two viruses are not closely related, but the test is less reliable in this negative sense because strains known to be related from serological studies do not always protect against each other.

A cross-protection test was carried out to see whether the mild mosaic strain would protect plants against the vein-banding and the severe mosaic strains. Three Lambournes with mild mosaic symptoms were inoculated with the vein-banding strain and three with severe mosaic, two Lambournes without symptoms being inoculated with each as controls. The control plants inoculated with severe mosaic did not develop symptoms, so this part of the experiment was inconclusive. However, the control Lambournes developed conspicuous symptoms of the vein-banding type, whereas those which were previously infected with the mild mosaic strain have continued to show only mild flecking symptoms. It appears, therefore, that the mild strain prevented the multiplication of the vein-banding strain, suggesting that both may be closely related strains of the same virus.

Discussion and description of the symptoms of the virus strains.

A puzzling feature of these experiments has been the inconsistent behaviour of the severe mosaic strain. In the first experiment described and in those using rootstocks and mature trees as test plants, the severe strain was transmitted as readily as the others ; yet in the two other transmission experiments and in the cross-protection test, no symptoms of the severe strain developed, although the source of grafts used for infection was the same in all experiments except the first.

This inconsistency is not related to ' graft take ', as there are trees without symptoms with grafts still alive, while some trees on which the grafts finally failed nevertheless developed symptoms. Neither is it due to varietal resistance, because that assumption would require Cox's Orange Pippin and Bramley's Seedling to be susceptible in one experiment and resistant in another. A possible explanation is that the virus was not fully systemic, so that some graft-wood was infected and some was not. The even distribution of symptoms on the Bramley's Seedling tree from which the graft-wood was taken does not support this hypothesis, however, and further investigation is required before a satisfactory explanation can be offered.

These experiments have shown that three types of apple mosaic can be transmitted with consistent differences between their symptoms. Because of the general resemblance in symptoms and the evidence that two are related, it seems preferable to refer provisionally to the three types as strains of the apple mosaic virus, rather than to consider the severe type as a distinct virus.

The symptoms of apple mosaic comprise four categories :

(*a*) White or pale yellow flecks often on a veinlet, but frequently bearing no regular relationship to the veins ; (*b*) large white or pale yellow areas extending over two or more of the interveinal areas separated by the main veins ; (*c*) vein-banding, where the primary and secondary veins are banded by white or pale yellow strips ; (*d*) necrotic areas, which usually develop on the chlorotic patches of type (*b*).

There is no symptom diagnostic of the different virus strains, and, therefore, the differences between them can be described only by reference to the frequency and degree to which categories (*a*) to (*d*) occur.

The severe mosaic strain.

The severe strain of mosaic causes pronounced symptoms of all categories on Bramley's Seedling (Fig. 1). The preponderance of large chlorotic areas which are bright yellow in early summer and gradually fade to white, naturally results in comparatively few small flecks. Vein-banding is well-developed, particularly on the younger leaves on the extension growth. Symptoms of mosaic are

generally less frequent and less severe on the later-formed leaves, but, whereas with other strains they are usually sparse or entirely absent on the younger leaves, this severe strain causes symptoms on leaves almost up to the tips of the extension growth. Large necrotic areas develop on the older leaves, and there is considerable defoliation.

The vein-banding strain.

The vein-banding strain in Bramley's Seedling, Cox's Orange Pippin, Hormead Pearmain and Lord Lambourne causes symptoms of all categories, but banding of the primary and secondary veins is most conspicuous ; banding of the tertiary veinlets in the form of a yellow network often occurs (Figs. 1 and 2). Small flecks on or between the veins occur more frequently than large chlorotic areas. Necrosis sometimes accompanies these large areas, but is relatively slight and defoliation seldom occurs. In comparative transmission tests, the symptoms of this strain on Bramley's Seedling, M.VII and M.IX rootstocks were paler yellow and more confined to older leaves on the extension growth than were those of the severe strain. In M.VII, some of the bands were separated from the veins and tended to form rings.

The mild mosaic strain.

The mild mosaic strain is characterized by the absence of necrosis and the rarity of vein-banding and large chlorotic areas in all varieties tested. The predominant symptom is flecking with comparatively few flecks and only a few leaves affected (Fig. 2). Probably the commonest strain of mosaic, it is often overlooked because the symptoms are so inconspicuous.

Summary.

The transmission of different symptom-types of mosaic by grafting to several apple varieties has demonstrated the existence of three distinct types. Evidence of cross-protection suggests that they are caused by related virus strains and the names " severe mosaic strain ", " mild vein-banding strain " and " mild mosaic strain " are used.

Reference

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THE RUBBERY WOOD VIRUS AND APPLE PROPAGATION

By A. F. POSNETTE and R. CROPLEY

Introduction.

The symptoms of the Rubbery Wood disease have been described by Luckwill and Crowdy (1950) and by Prentice (1950), and a detailed description here is, therefore, omitted. The rubbery feel of the branches is due to incomplete lignification of the wood ; apart from its diagnostic value, this rubberiness is of less economic importance than the stunting effect of the virus. Although rubbery trees are smaller than healthy trees of the same age, they appear to crop well for their size, and bear normal fruit, provided they are not suffering also from Chat Fruit disease, a distinct malady which may affect both rubbery and non-rubbery trees.

A puzzling feature of the Rubbery Wood disease has been its sporadic appearance in nursery trees which had been propagated from the same apparently healthy Lord Lambourne mother trees. Nurserymen have reported that a proportion of their young trees have been rubbery each year, despite roguing and changes in the scion source from one normal Lord Lambourne tree to another. A possible explanation of this occurrence was that the virus was latent in most normal trees and was not fully systemic, but restricted to localized areas along the stems cut for bud or graft wood. Another possible explanation was that the virus was present in a proportion of the rootstocks. This was supported by the occurrence of the disease in trees budded on clonal rootstocks and its absence from trees on seedling stocks. Until the virus nature of the disease was demonstrated, however, this evidence was interpreted as a rootstock effect. In 1950, Luckwill and Crowdy (*loc. cit.*) reported that certain rootstocks at Long Ashton were apparently carrying the virus ; meanwhile investigations were begun at East Malling in 1949, after consultation with Long Ashton, to ascertain the position.

The method of testing the rootstocks.

When the East Malling stoolbeds were harvested in the autumn of 1949, 12 stools were selected at random in the beds of M.I, M.II, M.IV, M.VII, M.IX and M.XVI, together with two stools of M.III. Five layers were taken from each stool and lined out in separate groups. Each layer was budded in July 1950 with Lord Lambourne taken from one of five different non-rubbery trees, so that from each stool five maiden trees from five different scion sources were obtained. Five sources of Lord Lambourne were used in the hope that at least one would prove uncontaminated with the rubbery wood virus. A total of 50 ' free ' seedlings of Cox's Orange Pippin and Worcester Pearmain were budded with the same Lord Lambourne scions as controls, together with a variable number of other rootstocks, not taken from selected stools, including five of M.XII and five of Crab C. Eighteen rootstocks of M.III and 24 of M.VIII which had been bought in from a nurseryman were also budded in the same way.

The rootstocks on which buds failed were grafted in the spring of 1951 with scions from the same source of Lord Lambourne as originally used.

Results.

When the maiden trees were tested by hand-bending in the autumn of 1951, it was found that all the trees on all the rootstocks except M.I, M.IX and the bought-in M.III and M.VIII were normal as were those on the control seedlings. This indicated that the five scion sources were all free from rubbery wood virus. Of the trees on M.I, however, 15 were definitely rubbery, the stocks of which came from six of the 12 stools examined, On M.IX 39 trees were rubbery, involving stocks from 10 of the 12 stools (Fig. 1).

All 18 of the trees worked on the bought-in M.III were rubbery, in direct contrast to those on the 10 M.III rootstocks from the Malling stoolbeds, none of which was rubbery ; 23 of the 24 trees worked on the bought-in M.VIII were also rubbery.

There was no difference in rubberiness between maidens grown from autumn budding and those from spring grafts.

Discussion.

This experiment definitely disproves the suggestion that rubbery wood is purely a rootstock effect, since it showed that both normal and rubbery Lord Lambourne trees could be grown on M.I,

M.III and M.IX. In this it supports many other observations, and also the work of Luckwill and Crowdy, who reported normal and rubbery trees on M.I, M.IV, M.VII, M.IX, M.XII and M.XVI. In addition, this experiment also shows that the ability to induce rubbery wood is a property of a particular stool; and warrants the conclusion that some stools are virus-infected and some are not.

In early years, before the presence of virus diseases in fruit trees was suspected, it was not unusual to propagate from stocks which had been unsuccessfully budded or grafted. For virus transmission to occur it is not necessary for a bud or graft to 'take' in the horticultural sense; a temporary callus union is often sufficient, and, although a shield in which the bud dies is a failure from the propagation stand-point, it may be quite satisfactory as a means of virus transmission. Leaf symptoms of mosaic were shown by 30 per cent of the M.III and M.VIII rootstocks which were bought in from a commercial nursery, indicating, in the absence of any known means of natural transmission, that they had been budded or grafted at some stage in their history with infected scions; it is significant that all these stocks also infected their scions with rubbery wood virus. This emphasizes the danger, already stressed in relation to cherry viruses, of propagating from stocks that have once been budded or grafted, whether the scion 'took' or failed.

The rubbery wood virus is not confined to Lord Lambourne. There is ample evidence from top-working that the virus occurs in many other varieties, and, although we know that it does not cause rubberiness in most of them, we do not know what other and less easily detectable effects it may have. This aspect of the problem is now being investigated, but in the meantime we cannot assume that the virus has no effect on the vigour of a particular variety merely because it does not show rubbery symptoms. An extensive programme for testing both rootstocks and scion varieties is now in progress. Scion varieties in the main field trials at East Malling are being tested by 'double grafting'. M.II, which gave no rubbery wood in either the experiment described above or in the Long Ashton investigation, is being used as the stock, the scion under test as the intermediate, and healthy Lambourne as the top-scion. If the test-scion is infected, the Lord Lambourne should develop into a rubbery tree.

It is, of course, impossible to predict the extent of infection in these scion varieties, but it must be anticipated that many trees may have become infected from the rootstock. It is clear that it is as important to have virus-tested mother trees for scion wood as it is to produce virus-free rootstocks.

All Malling apple rootstocks are now being tested extensively, using the same stool-testing method described in this paper. The most important asset of a clonal rootstock is its uniformity, and as soon as a virus disease infects some plants in a clone and not others, the clone is no longer uniform. For this reason alone and as a general safeguard, the Malling apple rootstocks are to be re-cloned, i.e. propagated again from a single plant which has been tested and found to be free from known viruses. In the meantime, there is no reason to stop the distribution of the Malling stocks in the stoolbeds in which virus has not been found, but, since healthy rootstocks cannot be distinguished by eye, the distribution of M.I and M.IX from East Malling has ceased until tested clones are available.

Summary.

Using the sensitive variety Lord Lambourne, the presence of rubbery wood virus has been demonstrated in the stoolbeds of the clonal apple rootstocks M.I and M.IX at East Malling. Six out of 12 tested stools of M.I were infected, and 10 out of 12 of M.IX. Tests on M.II, M.III, M.IV, M.VII, M.XII, M.XVI and Crab C from the Research Station beds were negative, but stocks of M.III and M.VIII bought-in from a commercial nursery were entirely infected. The current investigations on the virus-status of rootstocks and scion varieties are discussed.

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Prentice, I. W. (1950). Experiments on Rubbery Wood disease of apple trees. A progress report. *Rep. E. Malling Res. Sta. for 1949*, 122-5.

Fig. 1.

Lord Lambourne on M.IX.
Back : Normal maidens on four stocks from one stool.
Front : Rubbery maidens on stocks from another stool.

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NEW VIRUS DISEASES OF *RIBES*

By A. F. POSNETTE

Introduction.

Three virus diseases of *Ribes* species in Britain have been described in the past—Reversion of black currant (Amos and Hatton, 1927), Leaf-distortion of gooseberry (Gray, 1949) and Ring Spot of red currants (Klesser, 1951). Other *Ribes* virus diseases have been described in the U.S.A. (Hildebrand, 1939), Czechoslovakia (Blattný, 1930) and Germany (Winter, 1940), but none causes symptoms similar to the diseases described in this paper.

Vein-banding disease of gooseberry (*Ribes grossularia*).

This disease is so prevalent in Kent that symptoms have been seen on most of the gooseberry bushes inspected by the writer.

Symptoms.

The diagnostic symptom is a pale yellow banding of the primary and secondary veins (Fig. 1). The bands are cleared and semi-transparent, so that they appear brighter by transmitted than by reflected light. The banding starts from the veins without any interposed green tissue. Frequently, the banding is restricted to a part of the leaf, which is then distorted by the reduced growth of the affected side. The leaves may also be slightly mottled in two shades of green.

Infected bushes may bear small, crinkled leaves and be stunted in comparison with healthy plants (Fig. 2), but there is considerable difference between varieties in tolerance and symptom-expression.

The leaf symptoms may be confused with a type of yellow vein-banding caused by aphids (e.g. the Currant-lettuce aphid, *Hyperomyzus lactucae* (L.)). Aphid toxicity causes a yellower and less transparent banding, however, and the virus vein-banding is visible on young leaves unfolding in the spring before aphid attack has commenced.

Transmission.

By grafting.—The first transmission of this virus was observed in 1950 on three plants of an unknown variety affected by a non-infectious condition known as 'giant gooseberry'. The 'giant' gooseberries had been inarched in July, 1949, to three Leveller gooseberry bushes, on which the vein-banding had been observed previously, to test the transmissibility of the 'giant' condition, but the only result was that the vein-banding virus was transmitted from the Levellers to the 'giant' plants.

In May, 1950, an attempt was made to transmit the virus to ten young gooseberry seedlings by inserting strips of infected leaf under flaps of bark cut in their stems. This method gave no transmission. The grafts died on two seedlings which were saddle-grafted as controls, but one of these seedlings developed vein-banding symptoms on new shoots near the graft and has grown into a typically infected plant.

By insects.—The virus was transmitted readily by the Lettuce aphid, *Nasonovia ribis-nigri* (Mosley), but not by *Hyperomyzus lactucae* under comparable conditions. The aphids were fed simultaneously, but in different compartments of the insect-proof glasshouse, on detached shoots of Careless gooseberry with vein-banding symptoms, and then transferred to recently germinated seedlings from open-pollinated Keepsake and Leveller bushes. In the first experiment both aphid species were transferred after a 3-day infection feed, and in the second both species were allowed a 10-day infection feed. An infected seedling from the first experiment was used as the infector in the third experiment to confirm transmission by *N. ribis-nigri*. One test was carried out with each of the species *Aphis schneideri* Born and *A. grossulariae* Kaltb. before their seasonal migration to alternative hosts terminated the experiments.

In these experiments, symptoms were first observed on the Leveller test seedlings one month after they had been infected, but the infected Keepsake seedlings developed symptoms only after two to five months. No control seedlings became infected (see Table I).

Vein-pattern disease of black currant (*Ribes nigrum*).

This disease was first noticed at Harrietsham, Kent, in July, 1949, on a single Baldwin black currant bush. Cuttings rooted from this plant have provided the inoculum for the tests described here.

TABLE I.

APHID TRANSMISSION OF GOOSEBERRY VEIN-BANDING DISEASE.

Aphid.*	Experiment number.	Infection feed (days).	Test feed (weeks).	Aphids per plant.	Infection rate.	
					Leveller.	Keepsake.
Nasonovia ribis-nigri	1	3	2	10	9/10	3/5
	2	10	2	10	0/5	4/10
	3	2	2	5	2/5	—
Hyperomyzus lactucae	1	3	2	10	0/10	0/5
	2	10	2	10	0/4	0/5
Aphis schneideri	4	23	1	10	1/5	—
A. grossulariae	5	7	2	5	1/4	—

* Provided and determined by Dr. G. H. L. Dicker.

Symptoms.

The diagnostic symptom of this disease is a bright yellow banding of the primary and secondary veins. The bands are closely applied to the veins when near the leaf margin, but are separated by a widening strip of green tissue as they approach the midrib (Fig. 3). The bands usually join to form a line pattern. The symptoms are of the same general type on the two varieties, Baldwin and Wellington XXX, on which the disease has been observed.

On cuttings from an infected bush, the first symptoms developing in the glasshouse in early summer were faint, finely-drawn yellow rings, but these have not been recorded in the field.

Transmission.

Four three-year-old bushes of Baldwin and four of Wellington XXX were inoculated by bark grafts in August, 1950. All these plants had developed vein-banding by July, 1951, the symptoms usually being confined to the inoculated shoot or branches arising from it. None of the alternate bushes left ungrafted as controls showed symptoms. No transmission by insect vectors has so far been obtained.

Black Currant Yellows.

Cuttings of Seabrook's Black with leaf symptoms of this disease were brought to the writer by Dr. I. W. Prentice in August, 1949, from near Oxford. The disease has not so far been seen elsewhere.

Symptoms.

No symptoms appear until the young leaves are fully expanded and approaching maturity. The first symptom to appear is a yellow flecking on the fine veins. A yellowish-green mottle develops progressively as the leaves mature, and by the end of June, segments of affected leaves are yellowish-green, contrasting with the normal, or darker than normal, colour of the rest of the leaf (Fig. 4). Slight puckering of the interveinal areas often accompanies the yellow pattern.

The yellowish-green mottle caused by this virus should not be confused with a pale yellow mosaic, sometimes accompanied by veinlet banding (Fig. 5), which is common on the variety Daniel's September Black. This variegation has not been transmitted by grafting in our experiments.

Transmission.

Four plants of Baldwin and four of Wellington XXX were infected with yellows by bark grafts, and developed symptoms on the grafted shoots in the following year. The virus appears to travel slowly through the plant ; even on plants infected for two years, symptoms were usually confined to shoots arising from, or near to the inoculated branch. No transmission by insect vectors has yet been observed.

Discussion.

Owing to the lack of suitable test plants, only a few trials were done with possible insect vectors of the two black currant viruses. No transmission was obtained, but the numbers of tests were inadequate to establish that the aphid species concerned are not vectors. Host range studies are likewise incomplete, so that there is no absolute proof that the gooseberry vein-banding virus is not also the cause of one of the black currant virus diseases. The evidence strongly suggests, however,

Fig. 1.
Leaves of Careless gooseberry with symptoms of vein-banding virus disease. Healthy leaf at top left.

Fig. 2.
Effect of vein-banding on vigour of Leveller gooseberry seedlings. Left, infected ; right, healthy.

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FIG. 3.
Symptoms of Black Currant Vein-pattern virus disease on Wellington XXX (left) and Baldwin (right).

FIG. 4.
Symptoms of Black Currant Yellows virus disease on Wellington XXX (left) and Baldwin (right).

FIG. 5.
Variegation, probably not transmissible, on black currant Daniel's September Black.

that the gooseberry virus is distinct from either of these black currant viruses. Gooseberry Vein-banding is very prevalent and readily transmitted by aphid species which also attack black currant, but both Black Currant Yellows and Vein-pattern are rare diseases at present.

Gooseberry Vein-banding has stunted the seedlings infected by aphids (Fig. 2) and appears to reduce the vigour of some varieties. There are no experiments from which the effect on yield can be estimated. The virus is so readily transmitted by aphids that control is likely to prove difficult. Two obvious preliminary steps are the propagation of healthy material and effective spraying to control aphids.

Black Currant Yellows and Vein-pattern are rare diseases and, as long as care is taken in propagation, familiarity with the symptoms should ensure that they remain rare.

Summary.

The symptoms of three new virus diseases of *Ribes* are described. The diseases are named Gooseberry Vein-banding, Black Currant Vein-pattern and Black Currant Yellows. Each was transmitted by grafting. Gooseberry Vein-banding was transmitted by *Nasonovia ribis-nigri*, *Aphis schneideri* and *Aphis grossulariae*.

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FIELD STUDIES ON VIRUS DISEASES OF STRAWBERRIES I. THE RATE OF VIRUS SPREAD IN THE VARIETY AUCHINCRUIVE CLIMAX

By A. F. POSNETTE and R. BOVEY*

Introduction.

Recent investigations, which have been concerned chiefly with the separation of component viruses from the complexes responsible for the diseases in the field, have led to a better understanding of the factors involved in the degeneration of strawberry stocks. Prentice (1946, 1948, 1949) and Wood and Whitehead (1947) have shown that three viruses are concerned, each with different virus-vector relationships. Further analysis has suggested that Prentice's three viruses are better considered as virus groups with short, intermediate and long persistence respectively in the aphid vector (*Pentatrichopus fragaefolii* Ckll.), since there are viruses or strains with distinctive symptoms in each group.

It is important to study these virus groups in the field, in order to see in what way their vector relationships influence their rate and pattern of spread and how control measures can best be applied to reduce their incidence. Several experiments were conducted on these aspects of the problem in 1950-1; the one described in this introductory paper was intended to provide basic information on the rate at which viruses would enter and spread within an originally virus-free plot of strawberries.

Experimental material.

The variety Auchincruive Climax was used because it was the only variety which fulfilled the following requirements :

(*a*) plants must have been virus-free when planted and

(*b*) plots must have been planted in successive years from 1947 to 1950, so that the annual increment in virus infection could be estimated.

Five such plots were selected for examination and relevant details concerning them are given in Table I. It will be noticed that they differed in the proximity of other varieties, three plots containing virus-carrying varieties such as Huxley, while two consisted entirely of Auchincruive Climax. The plots were all situated in the same area of the Research Station, however, not more than 200 yards apart, the C5 plots being contiguous and similarly Plots E21 and E28.

TABLE I.

PARTICULARS OF THE PLOTS OF AUCHINCRUIVE CLIMAX.

Plot number.	Years planted.	Number of plants.	Spacing and other varieties present.
E28	1947	144	Spaced plants 18 by 36 inches : Perle de Prague, Huxley, Mme. Lefebvre, Early Cambridge.
C5a	1948	144	Spaced plants 18 by 36 inches : Perle de Prague, Huxley, Mme. Lefebvre, Royal Sovereign.
C5d	1949	4,800	Spaced plants 18 by 36 inches : all Auchincruive Climax.
E21a	1949	2,400	Comparison of spaced plants, matted rows and beds ; all Auchincruive Climax.
C5e	1950	144	Spaced plants 18 by 36 inches : Charles Lane, Huxley, Mme. Lefebvre, Early Cambridge.

The method of testing.

Greenslade and Pearce (1940) concluded that a sample of 75 plants was adequate for comparing aphid populations on strawberry fields of less than 50,000 plants. As it was desired to determine the presence or absence of virus on small plots, it was decided to use samples of 50 plants, which were selected at random in each plot between 15th May and 25th June. The samples were tested in two

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batches, each of 25 plants, by placing one young leaf from each plant in a Petri dish with a moist filter paper and infesting the leaf with 25 aphids (*Pentatrichopus fragaefolii*) from a virus-free stock. The Petri dishes were then stored in a cool place and the aphids allowed to feed for two days before being transferred to healthy plants of the Malling clonal *Fragaria vesca* for a test feed of seven days. These feeding periods were sufficiently long for the transmission of the mild crinkle and mild yellow edge viruses (Prentice's virus 1 and 2 respectively), but not long enough for the transmission of the crinkle virus (virus 3) ; however, more protracted feeding times on detached leaves were only practicable in cool weather.

Results.

Details of the results are shown in Table II. As all plots were autumn planted and the migration of winged aphids did not occur until the end of May, it was not expected that any plants put out in 1950 would have become systemically infected at the time of the test, and in fact, no transmissions were obtained. However, 10 per cent of the plants which had been planted in 1949, and, therefore, exposed to one aphid migratory period, were infected on both tested plots, while the samples from the plots planted in 1948 and 1947 contained 58 per cent and 100 per cent infection, respectively.

There were only two transmissions of the yellow-edge virus ; all the other 87 plants which became infected showed symptoms of mild crinkle only.

TABLE II.

AUCHINCRUIVE CLIMAX PLANTS GIVING VIRUS TRANSMISSION TO *Fragaria vesca*.

Year planted.	Plot number.	Number of plants infected out of 25:		Percentage infected.
		1st sample.	2nd sample.	
1947	E28	25	25	100
1948	C5a	14	15	58
1949	C5d	4	1	10
	E21a	2	3	10
1950	C5e	0	0	0

Discussion.

The plots which were sampled in this investigation had received routine sprays for the control of aphids. In 1948, nicotine dust was applied in July to control aphids after the spring migration ; in 1949 and 1950, parathion was applied at the beginning of May and end of April, respectively, to the 1947 and 1948 planted plots. The plots planted in 1949 received two Pestox III sprays in 1950, the first in early June and the second in mid-July. In 1951, all plots were sprayed with parathion at the end of April. These sprays differed from year to year according to the aphid population present and as new insecticides were tested.

Such sprays, although decreasing the numbers of aphids and sometimes practically eliminating them, have obviously not prevented a rapid increase in virus infection. The prevalent virus, mild crinkle, does little economic damage by itself, but is important as a component of the severe yellow-edge complex. Mild crinkle is readily acquired by aphids in feeding periods of 30 minutes or less and usually persists in the vector for less than three hours. As the aphids are infective immediately after acquiring the virus, this virus would be spread effectively by winged aphids making short flights from plant to plant and feeding for short periods while depositing their young. If the virus were carried into the plot to a few plants by the first migrants, successive migrations would pick up and spread the virus to other plants, and as the proportion of infected plants rose, the rate of spread would increase, until about 50 per cent of the plants were infected. Thereafter, with a low aphid population, one might expect the chances of the remaining healthy plants becoming infected to diminish as the aphids tended increasingly to move from infected to infected plants and as healthy plants became rarer. If, however, enough aphids were present to ensure that every plant was visited, all the remaining healthy plants would become infected in a single migratory period.

This is what appears to have occurred on the plots examined. Assuming that the amount of virus spread was approximately the same each year, about 10 per cent of the plants became infected in the first year after planting. During the second year, the degree of infection increased to about 50 per cent, presumably by spread within the plot as well as from outside ; and by the end of the third year, every plant in the oldest plot was infected.

This rapid saturation with virus emphasizes the urgent need for a means of general renewal of propagation stock from virus-free material annually, and also points to the ideal of the controlling of aphids *before* they can migrate from infected plants.

Summary.

When plots of the strawberry Auchincruive Climax were tested six months, one, two, and three years after planting with virus-free stock, samples were found to contain 0, 10, 50, and 100 per cent infected plants respectively. The importance of this finding in relation to special stock propagation is emphasized.

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AN INTENSIVE FIELD METHOD FOR TESTING FUNGICIDES FOR APPLE TREES

By M. H. MOORE

Introduction.

The Apple Scab fungus (*Venturia inaequalis* (Cooke) Wint.) is the obvious starting point for the development of a field method for testing fungicides, the need for which has already been briefly surveyed (Moore, 1947). This fungus is likewise one of the chief test organisms used in several laboratory precision methods, which can assist in fundamental structure/toxicity studies and provide early indications of fungistatic merit among the test chemicals, but may not necessarily indicate the best material to control disease under field conditions (but see Horsfall, 1945, page 18).

Precision testing with this fungus by greenhouse methods is more difficult, because the necessary quantity of apple trees in pots is inconvenient and costly to house and handle, and the trees are liable also to severe infection by Apple Mildew (*Podosphaera leucotricha* Ell. and Everh.), which may be difficult to control without interfering with the basic studies. This has led to the use of compactly-growing herbaceous plants in pots, but the results may be specific for each host/pathogen relationship. Each approach thus has its limitations, leaving possibly a wide gap between it and the established apple tree.

The devising of a field method to help fill this gap should preferably be based on multiple detailed observations to meet a lack of precision associated with this type of approach. Infection should be facilitated by simple and practicable means, for inadequate infection has sometimes in the past been a stumbling-block to progress in costly trials on established trees. Given adequate infection, perhaps the chief tool of the field pathologist, the mechanism of the actual testing procedure would follow as routine to be worked out to the best advantage.

The method to be described was devised on the basis of three essential pre-requisites for infection :

1. The presence of a susceptible *host*.
2. The proximity of suitable *inoculum* when the host is liable to become infected.
3. An immediate meteorological *environment* favourable for infection.

The form in which the host plant should be grown to enable natural infection to be most readily stimulated, and to meet the desire for large numbers of host units, was the first consideration.

EXPERIMENTAL MATERIALS AND GENERAL PRINCIPLES

Host.

Unworked apple rootstocks offered the following advantages for intensive outdoor work :

1. They can be vegetatively raised in large numbers from an established clone. As they are unworked, they are superior to young trees of selected scion varieties in that an expensive nursery practice is avoided ; also, they are available earlier.
2. They are genetically uniform, and individual variation is much less than in seedlings, with a consequent gain in experimental homogeneity.
3. They can be grown as a low hedge and pruned to produce a large crop of new shoots annually. As these are near the soil and clustered together, it is easier to maintain the humidity required for infection (Keitt and Jones, 1926) than would be possible among the branches of trees. They are simple to spray and manipulate.
4. Some rootstocks (e.g. M.III, M.VIII) are known from experience to be highly susceptible to Scab ; indeed, very severe natural infection was stimulated on an unworked bush of M.VIII in an earlier experiment (Moore, 1932, page 274).

A 240-foot East to West row of M.III rooted stocks was planted at 18 inches apart in December, 1941. The plants became established during 1942 ; they were cut down after planting, and a year later some of the resulting one-year growths were pegged down into the intervening spaces and lightly covered with soil. New shoots grew from these in spring, 1943, and reinforced the row. Surplus rooted shoots were used as the nucleus for building up a further supply of stocks for fresh plantings.

Inoculum.

Natural ascospore inoculum is not likely to be lacking in spring and early summer in a fruit-growing area (Fig. 1), but to ensure a superabundance and thus facilitate mass infection, the natural source was reinforced by scattering dead leaves containing mature ascospores along each side of the

row beneath the rootstocks. Limited use was made also of spraying conidial suspensions made from pure cultures on sterilized apple shoots (Montgomery and Moore, 1938), but this was abandoned early on account of the greatly increased manipulation entailed. Ascospores are naturally ejected over a long period, and the opportunity for fresh spores to meet favourable conditions for infection is, therefore, greater than from a single application of conidial suspension. Johnstone (1931) and others showed, moreover, that conidia are in general less satisfactory than ascospores as inoculum.

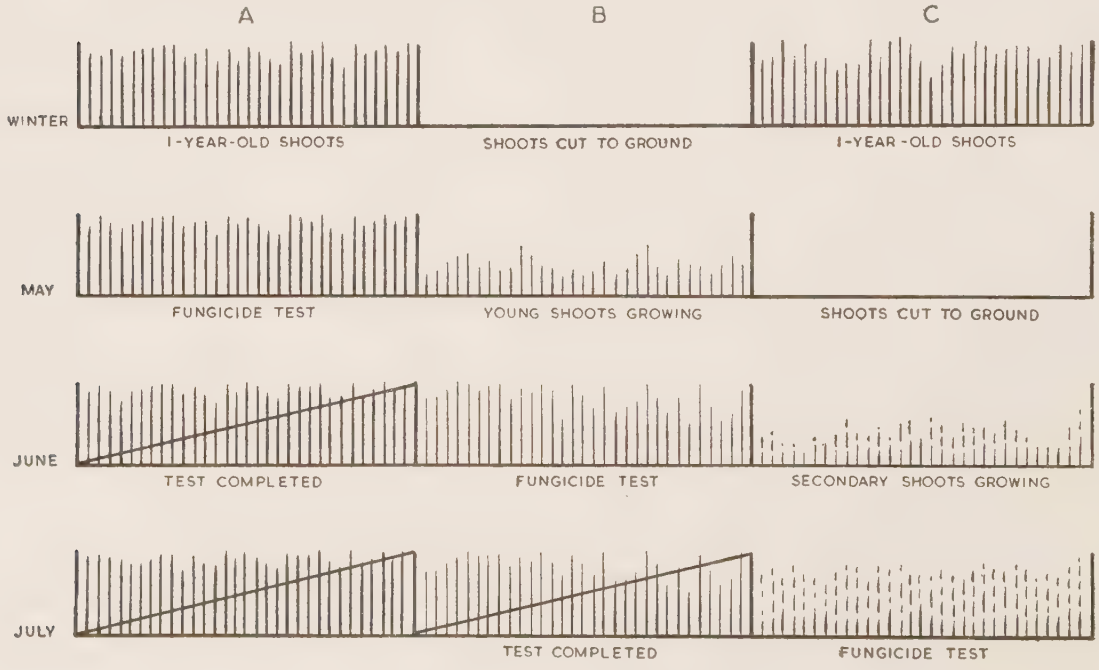
Environment.

The maintenance of high air humidity in dry surroundings outdoors was the most difficult obstacle. Exploratory tests were made towards providing the discontinuous wetting found by Keitt and Jones (1926) and others (reviewed by Moore, 1931) to favour infection, but little success attended mechanical sprinkling of the foliage until shelter was provided ; drying winds were inimical. The use of cloches was soon abandoned as inconvenient and unsatisfactory for this purpose. The tall, compact Timothy grass (*Phleum pratense*), grown in a 6 inch strip each side of and close to the row (Fig. 2) proved less convenient and effective than ' hop-lewing'* (Figs. 2, 3, 4), which was in addition readily available and easy to erect, and was thereafter used. Discontinuous wetting was more satisfactorily achieved by natural dew-formation above watered soil than by mechanical sprinkling as ' artificial rain ', which disturbs freshly-alighted spores. Dew-deposition is probably as important a factor in the incidence of Apple Scab and similar diseases as frequent rain (Moore, 1930, page 238), which, however, acts as an efficient dispersing agent for spores, and also replenishes soil moisture. Evaporation of this during warm days is followed by dew-deposition on cool nights ; the shelter restricts air movement thus tending to keep the moist air around the rootstocks, and also prolongs dew-retention.

THE METHOD

The row of stocks was divided into three equal parts in the winter, and pruning planned for each part to provide a succession of shoots until the summer. The preparations for any one test were made in the following order : erecting the shelter, trimming the stocks, marking out and labelling the plots, applying the sprays, laying down hay litter, distributing dead leaves, soaking the soil. Further details are given below, arranged for convenience of description and not in the above order.

TEXT FIG. 1. SEQUENCE IN USING APPLE ROOTSTOCKS FOR FIELD TESTING OF FUNGICIDES



Rotation No. 1:	1st year	A	B	C	Rotation No. 2:	1st year	A	B	C
	2nd year	B	C	A	(less satisfactory)	2nd year	C	A	B
	3rd year	C	A	B		3rd year	B	C	A

* Loosely-woven coir network (mesh approx. ½ inch square) used in lengths of 6 feet width for sheltering growing hops from damaging winds.

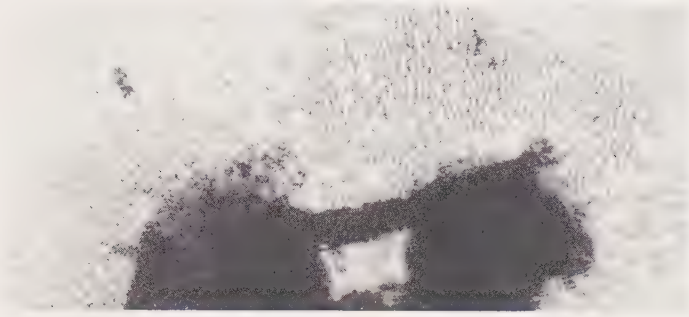


Fig. 1.

Ascospores of *Venturia inaequalis* recently released from mature perithecia in fragment of dead leaf of Bramley's Seedling apple. × 160 (approx.).

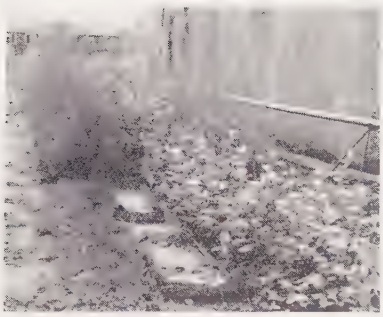


Fig. 2.

M.III apple rootstocks, lewing shelter, sprinkler pipe, Timothy grass (cut down in foreground), and gauze trays for dead leaves. An early experimental lay-out.

Fig. 3.

M.III rootstocks and lewing shelter each side of row. Note hanging wire trays containing dead leaves as reinforcement of inoculum in similar leaves scattered on the ground.

Fig. 4.

M.III rootstocks trimmed and sheltered ready for test, Series A (May) in background. Series B (cut down in winter) in foreground, growing up for test in June. Note water pipe for irrigation.

Fig. 5.

Continuation of row behind viewer in Fig. 4. In background, M.III rootstocks, Series C (July), to be cut to the ground at the end of May. Note flowering dwarf pyramids, the next level in the testing sequence.

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FIG. 6.

Secondary shoots of M.III rootstock, showing severity of Scab-infection induced in July (Series C), when the natural source of ascospore inoculum is exhausted.

FIG. 7.

Near view of unsprayed section of row of M.III rootstocks showing general severity of Scab-infection induced in July (Series C) on vigorous secondary shoots grown since the stocks were cut to the ground at the end of May.

Host. Pruning the plants to permit of tests in sequence during the season.

In an early overhead sprinkling experiment, the rootstock shoots were cut to ground level in winter to provide fresh leaves on young basal growths. Early infection was, however, confined to the foliage on a few small, one-year shoots that escaped pruning, though heavy foliar infection occurred later on the new shoots. This observation, together with the results of Experiment 1 (p. 143), led in 1947 to the adoption of a differential time of pruning the stocks as an integral part of the method, thus :

A. Stocks not cut down in winter yielded leaves on one-year-old shoots for infection tests in April or May (Fig. 4).
B. Stocks cut down in winter yielded leaves on current-year shoots for infection tests in June (Figs. 4 and 5).
C. Stocks not cut down in winter (Fig. 5), but cut down, say, at the end of May, yielded leaves on secondary current-year shoots for infection tests in July (Figs. 6 and 7).

The sequence is illustrated by the diagram (Text Fig. 1). A rotation is necessary to keep the plants small and to distribute the weakening effect of treatment C. Sometimes it might be necessary to spray the plants with a fungicide as a routine to prevent natural infection in advance of fungicide testing. Alternatively, the routine spray can be omitted to provide an opportunity to assess the therapeutic as well as the prophylactic value of the test sprays. The plants require spray treatment to control insect pests, and regular manuring to maintain good growth.

The pruning sequence raised the problem of providing a source of mature ascospores for the July series. Observations covering several successive seasons had shown that mature ascospores could not be found in dead leaves in the open plantation at East Malling after the third week in June ; at that period there were very few. Experiments were therefore made to investigate the provision of natural inoculum until at least July.

Inoculum. Providing dead leaves.

A source of numerous dead, scabbed leaves is essential. This may be a drawback in a region where Scab is not a troublesome disease, but the development of measures for its control would not then be important.

Several thousand scabbed leaves were collected each autumn from infected Bramley's Seedling trees just before leaf-fall. Picking them from the trees of only one host variety reduced the likelihood of using multiple strains of the fungus, and ensured that only scabbed leaves were selected, which is much more difficult when the leaves have become discoloured on the ground. They were kept all winter under natural conditions on a patch of grass in the open, a wire cage preventing their wind-dispersal. A cage of large ground-area is advisable so that the leaves are not heaped, otherwise they may rot. The leaves were brought indoors in spring when, and not before, they contained a modicum of mature spores. Too early transfer to dry surroundings may check, and even prevent, normal spore-maturation. Under the dry conditions of a shed it was found that mature spores could be kept in viable condition for over a year. This applied also to spores in series of leaves held under cold-storage conditions at 1°, —4°, —10°, and —20° C., but this method offered no advantage, and the simpler dry-storage was adopted. Leaves were removed as required during the spring and summer, a few being examined for spore-viability. The rest were then sprinkled along the stock row on each side. Some may be supported above the foliage (Fig. 3) to reinforce those on the ground, but this device was seldom used, for, like the gauze trays referred to below, it increases the time spent in manipulation. After each test, a few leaves were recovered and again examined to ensure that mature, viable spores had been present throughout the period of exposure.

Environment. Erecting the hop-lewing shelter, and watering the soil.

The construction of the shelter is illustrated in Figs. 3 and 4. A line of stout posts was firmly inserted each side of the row and about 4 feet from it, and the roll of material was opened out and tied to each post in turn, and to horizontally supporting cable-wire between them, so that the lewing was about 5 feet high and had a minimum of gaps at ground level. The corridor thus formed had open ends, but could be closed on the windward side in windy weather. A single layer of lewing was used at first, but a double layer was preferred later as giving more effective shelter. For a sequence of tests in different sections of the row, the lewing was easily taken down and transferred from one section to another.

The soil was watered freely from a hose (Fig. 4) care being taken to avoid splashing up soil on to the rootstock leaves. This was repeated every day if necessary to raise the air humidity, or continuous watering was maintained by using an oscillating-bar type of mechanical pipe sprinkler (Figs. 2 and 3), supported a foot or so from the soil and fixed so that the jets were directed towards the ground. The lewing was sprayed with water occasionally when dry conditions prevailed.

Worms pulled under the soil many of the leaves scattered over the moist surface. A sprinkling of DDT powder on the soil before scattering the leaves checked this tendency, and the use of 2- by 1-foot trays (Fig. 2) made from pieces of fine bronze gauze eliminated it. A layer of soil in each tray provided an approximation to the natural habitat. The trays allowed of only restricted leaf-distribution in contrast to general scattering ; they greatly increased the manipulation involved, and required storing when not in use. They were useful, however, in holding a standard number of leaves in position in appropriate experiments (pages 143-5). To economize their use they were placed alternately each side along the row.

Later, a layer of straw or hay litter laid on the soil before the dead leaves were scattered solved the worm problem, and also helped to prevent splashing from a hose and rapid evaporation of soil moisture in dry weather.

Spray Treatment. Applying the sprays.

Before the sprays were applied, the stocks were trimmed where necessary (Fig. 4) by the removal of straggling shoots, and by thinning out dense patches to give a uniform ' stand ' along the row. Lack of uniformity causes variability in microclimate and promotes uneven spray-application. Nevertheless, the stocks were not over-thinned, for moderate density aids infection by minimizing evaporation of surface moisture.

The sprays were uniformly applied as a fine mist from a suitable sprayer to labelled sections of the row (plots) according to a randomized arrangement of treatments, allowing adequate replication. If entire shoots are to be cut and examined for recording, the plot should preferably be not less than 3 feet long, or the choice of sample shoots is very restricted. If sufficient host-material is available, a 5 or 6 foot length is to be preferred.

Uniformity of application was facilitated by the allocation of a measured amount of spray for each plot, one half being applied from each side of the row. The provision of a small screen and of short buffer-lengths of row between plots to allow for spray-drift is a simple but desirable precaution.

Assessing Results Evaluating and recording Apple Scab lesions on the leaves.

About three weeks after the spray treatments had been given, every n^{th} shoot in a plot (avoiding a few inches each side of plot-junctions) was cut full length, and all fully developed leaves were graded for Scab on both surfaces recorded separately. The grades were : (1) up to $\frac{1}{8}$ (2) $\frac{1}{8}$-$\frac{1}{4}$ (3) $\frac{1}{4}$-$\frac{1}{2}$ (4) over half of the surface covered. Scattered lesions were grouped by eye, and this was facilitated by using the midrib as a convenient vertical division, across which appropriate imaginary lines at right angles divided the leaf into eighths. By this means leaf-size was integrated with the record. To reduce the amount of Scab-infection to one figure and thus facilitate direct comparisons, an *index of severity* was calculated as follows : a *mean grade* of infection per leaf (Moore and Pearce, 1946) was found by multiplying the number of leaves in any one grade by the grade-index value (1, 2, 4 or 8), and dividing the product by the total number of leaves scabbed. The ' mean grade ' was then multiplied by the *percentage* of leaves scabbed.

EXAMPLE : TO FIND SEVERITY OF SCAB INFECTION.

Total number of leaves on 10 sample shoots.		Number scabbed in grade : 0-$\frac{1}{8}$	$\frac{1}{8}$-$\frac{1}{4}$	$\frac{1}{4}$-$\frac{1}{2}$
	Grade index :	1	2	4
145		28	6	1
	Total of leaves scabbed	35		
(*a*) *% of leaves scabbed*	$= 3{,}500 \div 145$			$= 24{\cdot}1$
(*b*) *Mean grade scabbed*	$= \frac{(28 \times 1) + (6 \times 2) + (1 \times 4)}{35}$			$= 1{\cdot}3$
(*c*) *Index of severity*	$=$ (a) $\times$ (b)			$= 31{\cdot}3$

This method is similar to that devised in 1928-29 (Moore, 1930, pp. 233, 238) for computing the ' Scab Equivalent ' for pustules on apple twigs and lesions on fruits ; it differs in that ' percentage ' and ' mean grade ' can readily be extracted separately from ' index of severity ' but not from the ' Scab Equivalent ', which was computed directly from all (scabbed and non-scabbed) shoots or fruits examined without first finding the percentage scabbed.

It was usual to examine at least two complete and independent samples at each test. A more specific method of sampling adopted later was to pick and grade individual leaves (or, in the May series, a truss of leaves) from certain nodes on the sample shoots, which were selected as before and each marked by attaching a red-painted, spring-clip clothes peg. Greater accuracy ensued, as the sample was drawn only from the leaves present at the time of spraying ; moreover, the sample shoots were not sacrificed. Fresh, unsprayed leaves formed at each growing-point above the sprayed ones may become infected during the three to four weeks period of incubation and lesion development. If the period is long enough, depending on conditions, they serve as an additional source of (conidial) infection for the lower leaves, thus increasing the stringency of the test.

Either sampling method is suitable also for recording fresh infections of Apple Mildew, to which M.III stock is very subject, though with this disease obscure lesion-definition makes for tedium in accurate grading, except, perhaps, in bright sunlight, and categories for light, moderate, and severe infection per leaf are preferable.

EXPERIMENTAL DEVELOPMENT, 1946-48

Only selected experiments of a long series bearing on points of detail in the development and application of the method are described below.

1. Host.

The influence of type of shoot on foliar infection, 1946.

Four contiguous 30-foot lengths of stock row were each divided into six 5-foot plots. In each replicate the shoots of three plots selected at random had all been cut to the ground the previous winter, and those of the other three were unpruned. Leaf-inoculum was provided in May, but in the absence of shelter, early conditions were unsuitable for infection, which, however, occurred freely later and was recorded early in July. All leaves on a 20-shoot random sample per plot were examined, and the results are summarized (Table I) as Mean Severity per plot (12 plots per treatment).

TABLE I.

LEAF-INFECTION ON DIFFERING TYPE OF SHOOT.

Leaf surface.	Shoots of previous year.	Shoots of current year.
Upper	22·6	3·9
Lower	6·5	1·1

Differences are significant for both type of shoot and surface of leaf. Infection steadily increased later to become severe on the current-year shoots. Thus these are suitable for fungicide-testing work at a later stage than the one-year-old shoots.

2. Inoculum.

To test any influence of method of distribution of dead leaves on infection, 1948.

Two methods were compared on 8-foot plots (A) putting leaves in gauze trays alternately each side of the row, five leaves per tray (i.e. 20 leaves for each 8 feet), (B) scattering the same number of leaves every 8 feet within a strip 18 inches each side of the row. There were three randomized plots of each and four similar buffer plots (X) with no leaf-inoculum, arranged thus :

The experiment was started on 7th June in Section B (Text Fig. 1), the stocks having been cut down in winter. Lewing shelter and watering the soil as necessary were common to all plots ; frequent rain, however, made watering largely superfluous (R.H. 61·5 per cent ; mean of readings morning and afternoon among stock leaves in shelter from 7th to 21st June inclusive).

Foliar infection was recorded on three 10-shoot random samples per plot on 29th June to 1st July ; the data are summarized (Table II) as Mean Severity per plot :

TABLE II.

THE INFLUENCE OF METHOD OF DISTRIBUTION OF LEAF-INOCULUM ON INFECTION, JUNE, 1948.

Treatment.	Leaf infection on : Upper surface.	Lower surface.
A 5 leaves per tray	46·7	29·1
B Scattered leaves	87·6	51·8
X No leaves (buffer)	77·5	43·6

The differences for treatment are not significant, thus indicating that the spore-inoculum was ubiquitous, causing severe infection on all plots irrespective of the method of distribution of dead leaves, or even of the absence of leaf-inoculum on the buffer plots. The lower mean infection for A plots was probably due to a positional effect. The differences for leaf-surface effect are significant.

A similar experiment in July with the comparison : scattered leaves *v.* no leaves, was designed on the adjoining Section C (stocks cut down at the end of May), and included a continuous 24-foot length of row without leaf-inoculum. Foliar infection, recorded 4th to 6th August on two 10-shoot random samples, was even more severe, with a highly significant leaf-surface effect (Mean Severity on all plots : upper surface 132·4, lower 36·1), but the differences for treatment were again not significant. The only source of such general infection on this occasion was the artificially-retarded leaf-inoculum, as the natural source of ascospores was by then exhausted, and conidia are distributed only very locally and by water. The ubiquity of air-borne ascospores emphasizes a difficulty in buffering one experiment from the influence of another nearby.

3. Environment.

The influence of shelter on infection. Timothy grass and hop-lewing, 1947.

Experiments similar in design were made in June and July (Sections B and C, respectively, Text Fig. 1). The Timothy seed was sown in autumn, 1946 ; by the following June the compact grass was about 15 inches high, and the stocks about 12 inches. An 80-foot length of stock row was divided into eight equal plots, and lewing was erected to shelter four of these contiguously, the grass being common to all plots. Leaf-inoculum and irrigation as necessary to maintain humidity were provided.

June series.—The duration of dews (computed from thermograph readings and the Dew Point) over the first six days was 56 hours in lewing and grass and 45 hours in grass alone. Lewing slightly depressed the air temperature by day and slightly increased it at night, thus delaying dew-formation, but prolonging its persistence.

Results were recorded on two 10-shoot random samples per plot three to four weeks after exposure to inoculum, and are summarized (Table III) as Mean Severity per plot.

TABLE III.

THE INFLUENCE OF HOP-LEWING SHELTER ON FOLIAR INFECTION, JUNE, 1947.

Treatment : Grass.	Lewing.	Leaf infection on : Upper surface.	Lower surface.	% R.H. among stock leaves. Mean of observed values.
+	+	31·9	26·8	67·1
+	—	23·3	15·9	61·8

N.B.—Mean % R.H. at non-watered, non-sheltered site nearby was 56·3.

Infection was fairly severe, and was significantly increased by the lewing shelter, with no interaction effect for leaf-surface ; the differences for leaf-surface are, however, significant.

A noteworthy incidental effect of this lewing shelter was observed on a similar row of M.III stocks 4 feet to the North of the shelter and parallel to it. The stocks thus unintentionally sheltered were obviously much more heavily infected than those that extended beyond the shelter. Samples each of 10 shoots from 10-foot plots in each series showed Mean Severities for leaf-infection per plot of 59·2 (sheltered) and 20·0 (unsheltered). In this case the shelter was on one (South) side only, that of the prevailing wind, and the inoculum was presumably a mixed population of ascospores from this

experiment and surrounding plots. A similar, though more general, influence of one experiment on a neighbouring one was pointed out in Experiment 2 (July) in relation to air-borne inoculum.

July series.—The grass in four of the plots, two lewing-sheltered and two unsheltered, was cut to the ground at the start (Fig. 2), thus making four instead of two degrees of shelter treatment, viz. :

Grass — + + —
Lewing — — + +

The weather during the test period was noteworthy for high day temperatures, general calm, and occasional thunderstorms, with resulting high humidity little influenced by any of the shelter treatments. Heavy dews were frequent, and infection, recorded on two 10-shoot random samples per plot in early August, was severe, with a highly significant difference for leaf-surface. (Mean Severity per plot : upper surface 68·3, lower 30·9.)

Shelter treatments proved superfluous under the conditions of this experiment ; differences for treatment were not significant. It is noteworthy that, as in Experiment 2 (July), severe infection resulted from artificially-retarded leaf-inoculum when the natural source was exhausted.

In parallel experiments not presented here, grass shelter alone had no significant influence on the degree of Scab-infection.

A TEST OF THE METHOD.

A comparison of the rootstock method with the tree method of testing fungicides, using a simple range of lime-sulphur dilutions, 1947.

A comparison of this kind can be made satisfactorily only in spring before infection has become established on the trees. A short range of dilutions of lime-sulphur (LS), similar to that compared in the development stages of a laboratory testing method for fungicides (Montgomery and Moore, 1935), was tested in Section A (Text Fig. 1) on one-year-old shoots 15-18 inches high. Eight 10-foot plots included two replicates each of four treatments : (1) 1·0 per cent, (2) 0·5 per cent, (3) 0·25 per cent, (4) nil.

On 5th May, lewing shelter was erected, sprays were applied from a hand-operated solo sprayer, dead leaves (five per tray alternately each side of the row) were distributed, and the ground was heavily watered.

Next day, the same four spray treatments were applied, at Pink Bud, to twelve-year-old bush Cox's Orange Pippin trees on M.IX rootstock in an open plantation, with no added inoculum and no modification of the natural environment. Seven replicated blocks each contained four single-tree plots, on which the treatments were randomized. The sprays were applied at 300 lb. pressure per square inch from a 2 h.p. mobile machine. This half of the comparison represents the normal field testing procedure used at East Malling.

Scab-infection on the leaves of the rootstocks was recorded on two 16-shoot random samples per plot on 27th to 29th May, and during the same period on the Cox trees on 10 random rosettes of leaves on non-fruiting spurs from all parts of each tree. The results are summarized (Table IV) as Mean Severity per plot.

TABLE IV.

FOLIAR INFECTION ON M.III ROOTSTOCKS AND ON COX'S ORANGE PIPPIN TREES ON M.IX IN RELATION TO THE SAME FUNGICIDAL TREATMENTS, 1947.

Spray treatment.	M.III rootstocks.		Cox on M.IX.	
	Upper surface.	Lower surface.	Upper surface.	Lower surface.
Lime-sulphur :				
1·0%	0·6	0·0	0·8	0·9
0·5%	1·7	0·6	1·1	3·2
0·25%	4·8	1·2	0·8	3·2
Nil	11·4	4·9	0·6	6·4
Nil*	3·6	1·5		

* Similar samples drawn from unsheltered and non-irrigated M.III stocks nearby ; no inoculum provided.

The infection/treatment relationships were similar for rootstocks and trees, but the leaf-surface/host relationship differed significantly as regards Scab-infection, which was the heavier on the upper surfaces of the rootstock leaves and on the lower surfaces of the Cox leaves. The trees in spring present the *lower* surfaces of the unfolding leaves to the ascospores as they are whirled up through the branches. Among low-growing rootstocks, however, and especially when these are

sheltered, the ascospores freshly released from dead leaves nearby are slowly eddied among the young leaves before they attain enough height to be carried away by the wind above the shelter, as can be demonstrated by the use of smoke. While thus eddying, many of the spores will tend to fall back to the ground and be caught by the upper leaf-surfaces. The period observed from spray-application to recording (three to four weeks) would be too brief for secondary (conidial) infection to have much influence at this stage. Later in the season, however, and especially after wet weather, trees of susceptible varieties are more heavily infected on the upper than on the lower leaf-surface because conidia are splashed downwards from earlier infections established higher up.

Lime-sulphur was significantly more effective at 1·0 per cent than at 0·25 per cent in both series, and caused no damage. There was more infection on the unsprayed stocks with modified environment than on those under natural conditions, and more than on the unsprayed trees ; moreover, the infection gradient was the more uniform on the rootstocks. Hence, M.III rootstocks, with infection helped by the modified environment, should indicate control of foliar infection by fungicides at least as clearly as Cox trees on M.IX.

Discussion.

The method of fungicide testing described is intended to supplement and not to replace laboratory and greenhouse precision methods. It is intended also to precede and reinforce tests made on established cropping trees, whether grown intensively as dwarf pyramids or extensively as in the usual commercial plantation. A four-stage sequence of testing might thus be : (1) Precision tests in the laboratory or greenhouse (2) non-precision tests on rootstocks as indicated (3) on dwarf-pyramid trees (Fig. 5) with further detailed recording, in which the effect of the test chemicals on loss of crop and other indications of spray damage is specially observed, (4) on established plantation trees, as in early days when testing fewer materials, with perhaps less detailed recording, but with a keen eye to regional and economic comparison of candidate fungicides that survive the earlier, rigorous tests.

Interference by one treatment with another was illustrated by the experiments concerning inoculum and shelter. Evidence from one of the shelter experiments not reported suggested that the parallel lines of lewing could act as a wind-tunnel for the spores, so that unsheltered control stocks just beyond the leeward end became most infected. In the routine use of the method, most difficulties that are necessarily part of experimental development under field conditions will cease to intrude ; the provision of inoculum and shelter, for example, would be standard treatment. Where the area of available rootstock material is limited, the siting of each group of fungicide tests in relation to the others of a sequence in any one season should be considered at the outset, for then any likely inter-test influences may be anticipated and offset by appropriate design.

One point of special interest from the present study is that fresh ' out-of-season ' ascospore infection of suitably pruned apple rootstocks is possible in the open. Very severe Scab-infection occurred on secondary shoots in July, but it cannot be claimed that the method is, therefore, infallible, for circumstances occasionally may not yield sufficiently to artificial modification to provide the right conditions for infection. The greatest problem is persistent, drying wind. M.III stocks proved a convenient and practicable host, and because the testing season can be extended as indicated, experiments can be repeated quickly, thus offering one advantage over field experiments on cropping trees.

Rootstocks other than M.III, which is very susceptible also to Apple Mildew, would probably be suitable for this work, and some are under observation for Scab-susceptibility. Of these, M.XVI and M.II were the most infected in 1951. M.VIII is known to be very susceptible, and experiments show that it is a suitable host also for mass-infection by the Canker fungus (*Nectria galligena*), and can, therefore, be used for testing fungicides to control this disease. Rootstocks lend themselves also to nutrition experiments on disease, and should be suitable for pot experiments in the greenhouse, especially for the control of Apple Mildew.

Acknowledgements.

The writer is specially indebted to Mr. R. D. Souter for much help with the field work, to the Statistical Section for the analyses, and to the Superintendent of Ditton Laboratory, D.S.I.R., for cold-storage facilities.

Summary.

The method described is based on the provision of the following stimuli to natural infection by the Apple Scab fungus (*Venturia inaequalis*) :

1. The use of the apple rootstock M.III as the susceptible *host*. By pruning in sequence a supply of young shoots is made available for fungicide tests on fresh foliage in May, June, and July.

2. The provision of natural ascospore *inoculum* in dead apple leaves. When the spores are mature the leaves are air-dried, and viable spores are thus available when required during the season.

3. A measure of artificial modification of the natural *environment*. Air humidity is kept as high as possible by liberal irrigation and the use of fabric shelter to limit the dispersal of the moist air. Dew provides alternate wetting and drying favourable for infection.

By this means severe natural Scab-infection of the foliage was promoted on one-year-old shoots in May, on current-year shoots in June, and on secondary shoots in July when the natural source of ascospore inoculum was exhausted. The method is not infallible, for it depends, even with the modifications, largely on the natural environment, but it finds a place in a scheme of investigation ranging from precision laboratory tests to quasi-commercial tests on established plantation trees.

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NOTE ON INFECTION OF YOUNG PEACH SHOOTS AND OF LEAVES BY THE BROWN ROT FUNGUS, *MONILIA FRUCTIGENA*

By M. H. MOORE

During the past two seasons the writer's attention has been drawn to lesions on vigorous peach shoots of the current year, chiefly of the variety Peregrine, growing in the open. The lesions are smooth and brown, and at first small and circular ; some of them later rapidly become elongated along the axis of the shoot, often with copious external gumming, to form cankers that may girdle and kill the shoot. The early stages of infection appear to be associated with lenticels, as has already been noted for apple fruits (Moore, 1951). One of these gumming cankers, on a shoot more than $\frac{1}{2}$ inch in diameter, bore the familiar buff pustules of *Monilia fructigena* (Fig. 1), which, when inoculated into wounded apple fruits, produced the typical Brown Rot symptoms.

In August 1951 an attempt was being made in a private garden to convert an established tree of the variety Sea Eagle, bearing a few vigorous basal shoots of the current year, to the variety Peregrine. Healthy and freshly excised buds were inserted into these basal shoots using the normal T-shaped cut, though it must be emphasized that this process differs from the normal budding of nursery trees. Within a few days several of the buds and the surrounding host tissue began to rot, the wounds produced gum, and pustules of *M. fructigena* developed freely on the lesions (Fig. 2). There were numerous rotting peaches bearing similar pustules on branches growing above the budded shoots.

Several healthy Sea Eagle shoots were then collected from this tree and incubated in two large glass dishes, liberally lined with wet filter-paper on the bottom and around the sides. In each series a few leaves were snapped off at the base of the petiole, and a few wounds were made in the shoots by bending them to snapping point (Fig. 3). One series was inoculated by projecting into the dish from an atomizer a fine fog of droplets of distilled water passing across the edge of a freshly infected peach fruit freely sporing with *M. fructigena*. The spray removed spores from the pustules in transit and carried them amongst the leaves and shoots in the dish. This method avoids possible damage to the spores often caused when they are suspended in water, shaken up, and then projected with force through a small hole. The other series was sprayed with distilled water only, and each was kept continuously wet for several days afterwards.

Lesions similar to those seen in the open developed on the inoculated shoots both at the wounds and also where no visible wound existed, though lenticels were prominent, as is usual on most young peach shoots. Moreover, numerous dark lesions developed on the leaves, and some of them sporulated (*M. fructigena*) (Fig. 3). Transfers into wounds in healthy, ripe peach fruits from lesions on either shoots or leaves produced typical rot symptoms, and later spore-pustules of *M. fructigena*.

In apples, spur and branch cankers following fruit infection by *M. fructigena* are not uncommon (Wormald and Moore, 1945). It is, however, unusual for this fruit-rotting fungus to attack current season's shoots, which do not bear fruits, and also for it to infect leaves ; in the present series of observations the latter was seen only under artificial conditions. Heavy summer rainfall, concentrated within a few days with high atmospheric humidity—which occurred occasionally in 1950 and 1951—may be contributory, judging by the results obtained in the damp-chamber experiment.

There appears to be at least one other source of apparently similar gumming cankers on young peach shoots, for some lesions have been encountered that have not yielded the Brown Rot fungus. They may possibly be of virus origin, but this is at present uncertain, and their etiology remains obscure.

Acknowledgement.

The writer is indebted to Mr. J. H. Walker of the Scientific Liaison Section for calling attention to the symptoms described, and for providing specimens.

Summary.

Brown Rot infection (*Monilia fructigena*) was noted in vigorous peach shoots of the current year. Infection may occur through wounds or, apparently, through lenticels. Spore-inoculated, unwounded leaves also became infected.

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Fig. 1.

Current-year shoot of peach showing gumming canker bearing pustules of *Monilia fructigena*.

Fig. 2.

Budded peach shoot of current year, showing rot lesion bearing pustules of *Monilia fructigena* (indicated by arrows).

Fig. 3.

Spore-inoculated peach shoot and leaves bearing lesions of *Monilia fructigena*. Note that on the shoot these occur either at a node from which the leaf was broken off, or at a crack in the shoot, or internodally where no wound existed. Note also fructifications on some of the leaf lesions.

[face p. 148

A METHOD FOR THE STUDY OF THE EFFECTS OF VERTICILLIUM TOXINS ON THE WATER RELATIONS OF CUT SHOOTS

By P. W. TALBOYS

This note concerns one aspect of an investigation on the host-parasite relationship in the *Verticillium* wilt diseases of the hop and other plants.

Several mechanisms have been postulated to account for the characteristic symptoms developed as a result of vascular mycosis by such pathogens as *Verticillium* and *Fusarium*, and have been reviewed by Brown (1936) and Gottlieb (1944). The most widely accepted theory at present is that the pathogen growing in the vessels of the host plant secretes toxic substances which are carried in the transpiration stream to the leaves, where they induce physiological changes resulting in a disturbance of the water relations and the development of a characteristic symptom pattern. A tripeptide toxin, lycomarasmin, has been isolated from culture filtrates of *Fusarium lycopersici* in a pure state, and its effects on the water relations of tomato shoots have been examined by Gäumann and Jaag (1947) in experiments in which the rates of uptake and loss of water by the shoots were determined simultaneously.

Water uptake was measured by means of a calibrated potometer ; and, by recording the changes in the total weight of the potometer and shoot, an estimate of the water loss was obtained. The potometer with the shoot attached was mounted on a balance and counterbalanced. Changes in weight resulting from the loss of water by transpiration were photographically recorded on a drum by means of a lever and optical system which formed an extension of the balance beam (Gäumann and Jaag, 1936). Temperature, humidity and light intensity were maintained constant.

In the present investigation experiments on similar lines are being made to determine the effects of the secretions of *Verticillium albo-atrum* on the water relations of plants, but with a different form of apparatus (Fig. 1) in which the water transpired is estimated by absorption in sulphuric acid.

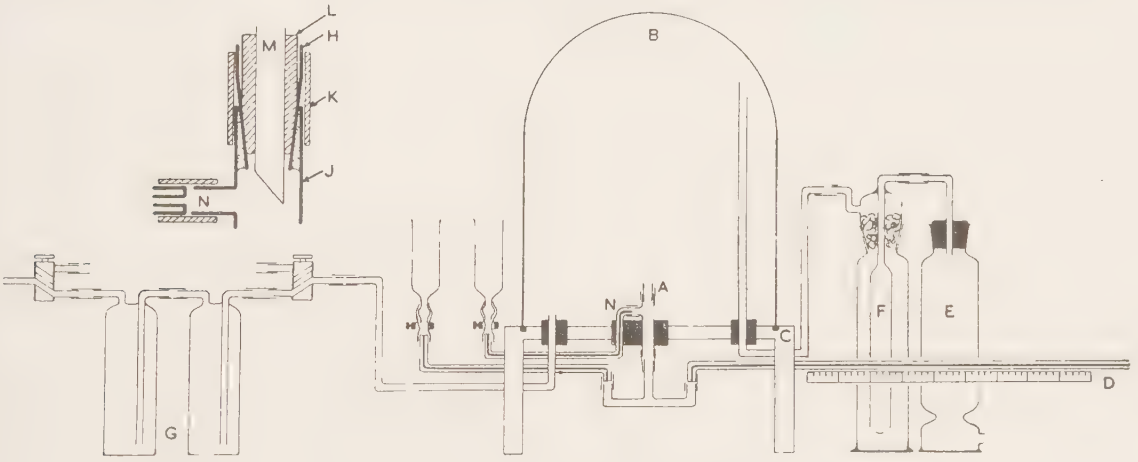

FIG. 1.

The apparatus ; for details see text.

The shoot in the holder (A) is enclosed in the bell jar (B) which is sealed into the channel in the base-board (C) with a mixture of paraffin wax and vaseline. Water uptake is determined by means of the calibrated potometer tube (D) and is expressed in gm/hr. Readings are normally taken at 15 minute intervals and plotted graphically to detect small fluctuations in the rate of uptake. A small vacuum pump draws air through two drying units (a calcium chloride tower (E) and sulphuric acid wash bottle (F)), and over the plant in the chamber, where the water vapour of transpiration is taken up and passed to a pair of sulphuric acid washing bottles (G) where it is absorbed, and its quantity determined by weighing the bottles at hourly intervals. By an arrangement of three-way taps as shown two sets of washing bottles are used alternately, one set being in operation while the other is being

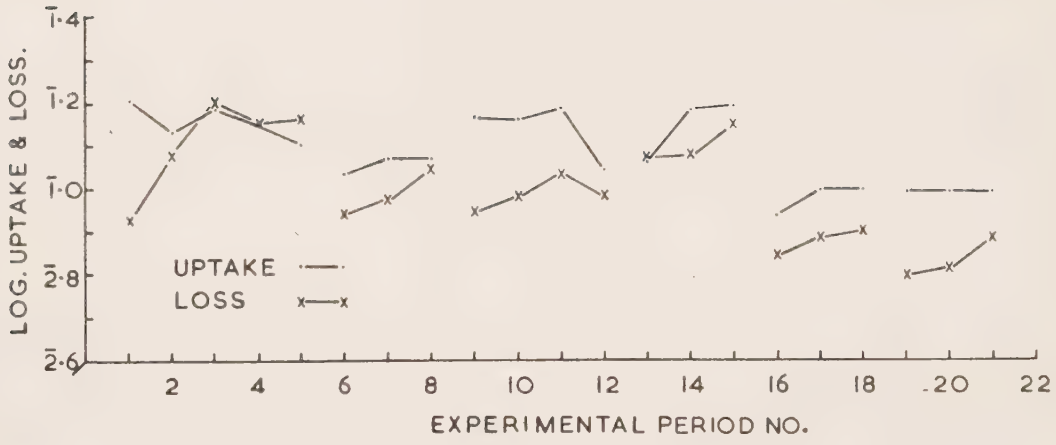

Fig. 2.

Water uptake and loss, using distilled water.

weighed, thus permitting the apparatus to be run continuously. A plug of glass wool in the top of the wash bottle (F) prevents sulphuric acid spray from entering the plant chamber. Water loss is expressed in gm/hr. The inset in Fig. 1 shows the detail of the plant holder. A very slightly tapered glass tube (H) is sealed into the end of a cylindrical one (J) by means of paraffin wax, and held securely by rubber tubing (K). A short piece of soft tubing (L) is fitted over the cut end of the shoot (M) under water, and this is pushed gently into the water-filled holder and sealed with a paraffin wax-vaseline mixture after the removal of excess water. A side tube (N) entering immediately below the shoot permits test solutions to be run in to displace the water in the potometer as required.

The results of two experiments with lateral shoots of hop plants give some indication of the type of result which is being obtained. In the first a hop lateral was maintained in the apparatus for eight days, with a continuous flow of dry air through the plant chamber and distilled water in the potometer. Records were made for several hours on each of six days (Fig. 2), and it is clear that after an initial period of erratic behaviour (a shock phase) there is a close balance between uptake and loss, with a general tendency for the uptake slightly to exceed the loss.

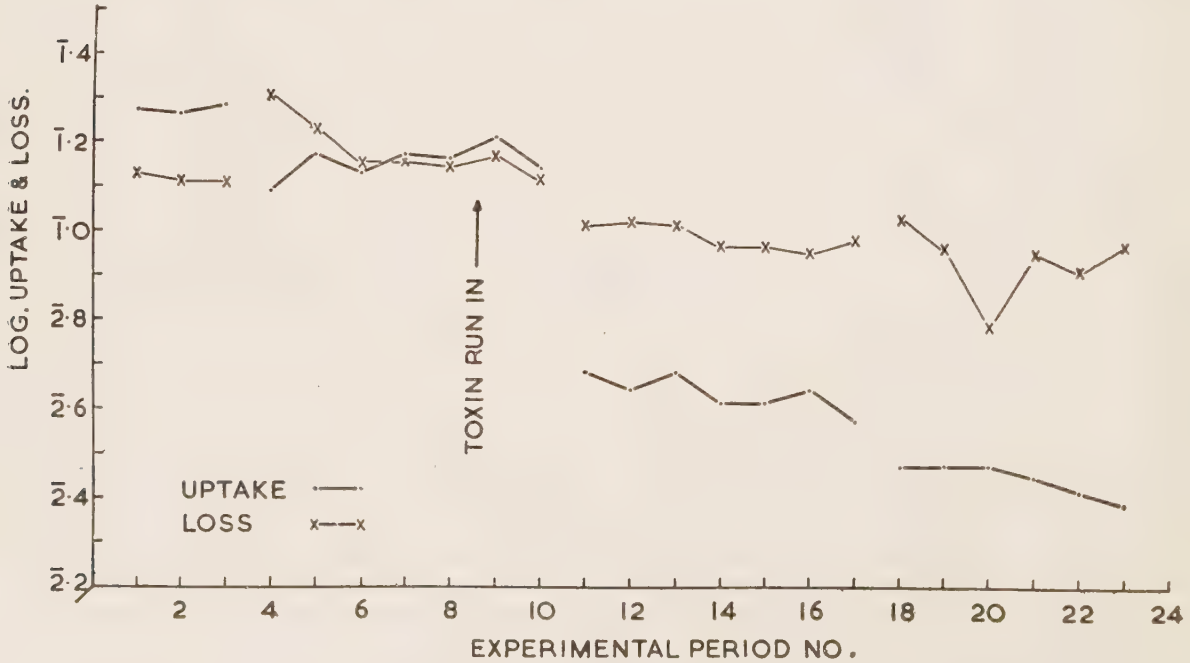

Fig. 3.

The effect of toxin upon water uptake and loss.

The effect of replacing distilled water with a *Verticillium* culture filtrate is indicated in Fig. 3. Records taken on four consecutive days show that the effect of the treatment was to change the water balance in such a way that the loss considerably exceeded the uptake, causing a progressive desiccation of the leaves. Studies on these lines are continuing.

Summary.

A method for the simultaneous determination of water uptake and water loss by a detached shoot, and its application to the study of the mechanism of symptom induction in *Verticillium* wilt diseases, is described.

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ENTOMOLOGY

A PRELIMINARY ACCOUNT OF THE SUMMER FRUIT TORTRICID, *ADOXOPHYES ORANA* (F.R.), IN GREAT BRITAIN

By JOAN R. GROVES

Introduction.

In Great Britain there are a number of species of Tortricidae which feed on fruit trees, causing damage to the fruit in the autumn. Up to the present, the commonest species has been *Cacoecia oporana* (L.) (= *C. podana* (Scop.)) (Hey and Thomas, 1934). The damage by these species has, with the advent of a fuller spray programme, greatly decreased. But in the past two seasons a new species has occurred which has caused characteristic injury distinct from that produced by other Tortricids. This species has now been shown to be *Adoxophyes orana* (F.R.) (= *Capua reticulana* (Hb.)) a moth new to this country (Groves, 1951a, 1951b). On the continent this species was known as early as 1834 (Fischer von Roeslerstamm) when it was found on birch trees in many parts of central Europe. It was not recorded on Rosaceae until 1910 (von Kennel), when it was noted on *Prunus* and *Rosa*, but not on fruit trees. Between 1940 and 1944 severe damage was caused to orchards in Belgium (Soenen, 1947) and in 1947 it became a pest in the Netherlands (de Jong, 1951).

It is proposed that the common name of this insect should be the Summer Fruit Tortricid. The full synonymy has already been considered (Bradley, 1952).

Occurrence in England.

The Summer Fruit Tortricid was first recorded in an orchard at Teynham, Kent, in 1950 (Groves, 1951a, 1951b). Since then many orchards in the north-east Kent fruitgrowing area have been found to be infested, and it has been found north of the North Downs, from the Medway estuary to the east coast of Kent at Sandwich. It has also been found in small numbers in the East Malling district, and at a farm a few miles south of Gravesend. Apples which appear to have been damaged by the Summer Fruit Tortricid have been found in a number of other areas of south-eastern England, but no moths or larvae have yet been seen to confirm these records. It seems likely, however, that by 1952 the species may prove to be more widespread than was at first supposed.

Description.

The adult moths have been described in detail by Bradley (1952). They are of a pale orange brown colour with darker markings on the wings. This pattern is more distinct in the male, which is slightly smaller (Fig. 1), having a wing span of 15-20 mm., compared with 19-22 mm. for the female. The larvae of the first instar are pale green with a black head, but at the first moult the head becomes pale fawn. The yellow eggs are laid in flat batches with the shells overlapping (Fig. 2).

Life History.

Other Tortricid species overwinter on the fruit trees as young larvae, usually second instar, emerging to feed on the unfolding leaves in the spring ; they pupate in May and the adults emerge in June or July according to the species. Eggs are laid within a few days and soon hatch ; the young larvae slowly develop to the second instar and then overwinter. These young larvae may damage the fruit. There is normally only the one generation every year.

In Great Britain the Summer Fruit Tortricid has two complete generations each year. In Belgium there is a partial third generation (Soenen, 1947), but so far no evidence of a third has been found in this country. Collections from bait traps and a mercury vapour light trap have shown that the first flight of adults, from overwintering larvae, occurred in 1951 from 23rd June until 26th July, and the second flight, of adults matured from larvae of the summer generation, from 18th August until 15th October. In 1950 no first flight was observed, only small numbers of second flight moths from 15th August until the end of September. But, as the population at East Malling was very small and only bait traps were used, these records are not comparable with the data for 1951.

Young larvae overwinter on the trees under a dead leaf webbed to the twig, between two shoots

Fig. 1.
The Summer Fruit Tortricid, *Adoxophyes orana* (F.R.). Adult male (left) and female (right).

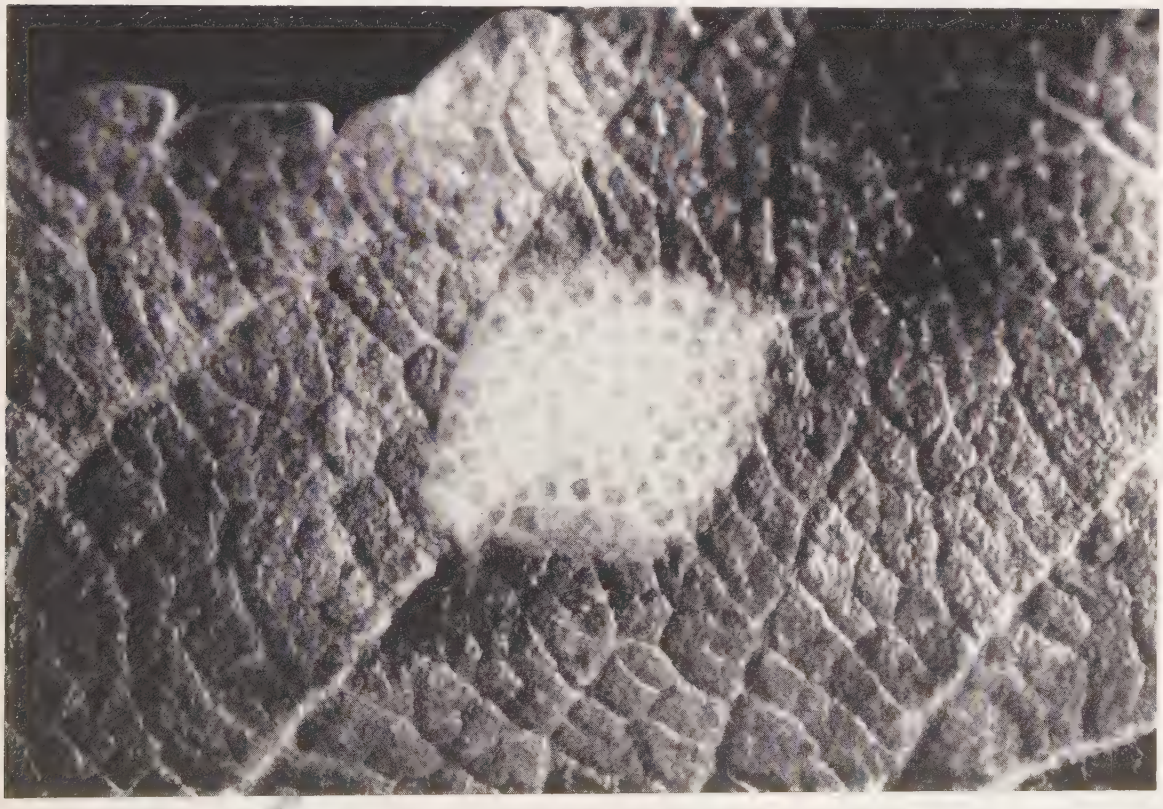

Fig. 2.
Egg batch on upper surface of apple leaf (×14).

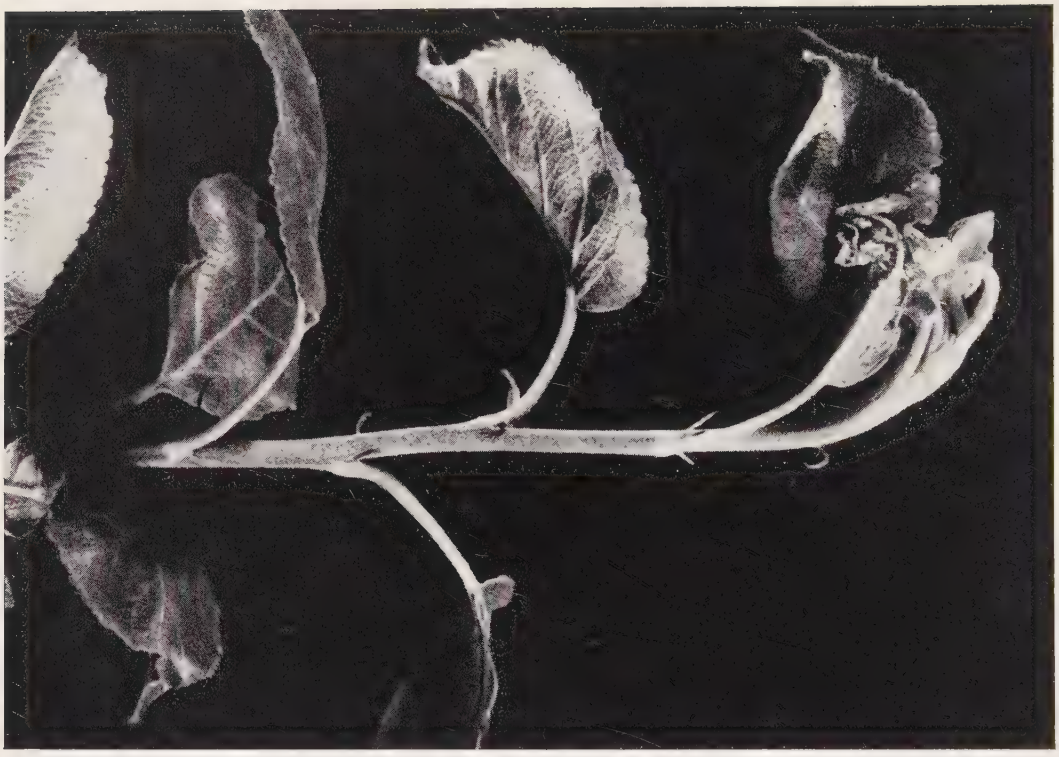

FIG. 3.
Damage to apple shoot by larva of the summer generation.

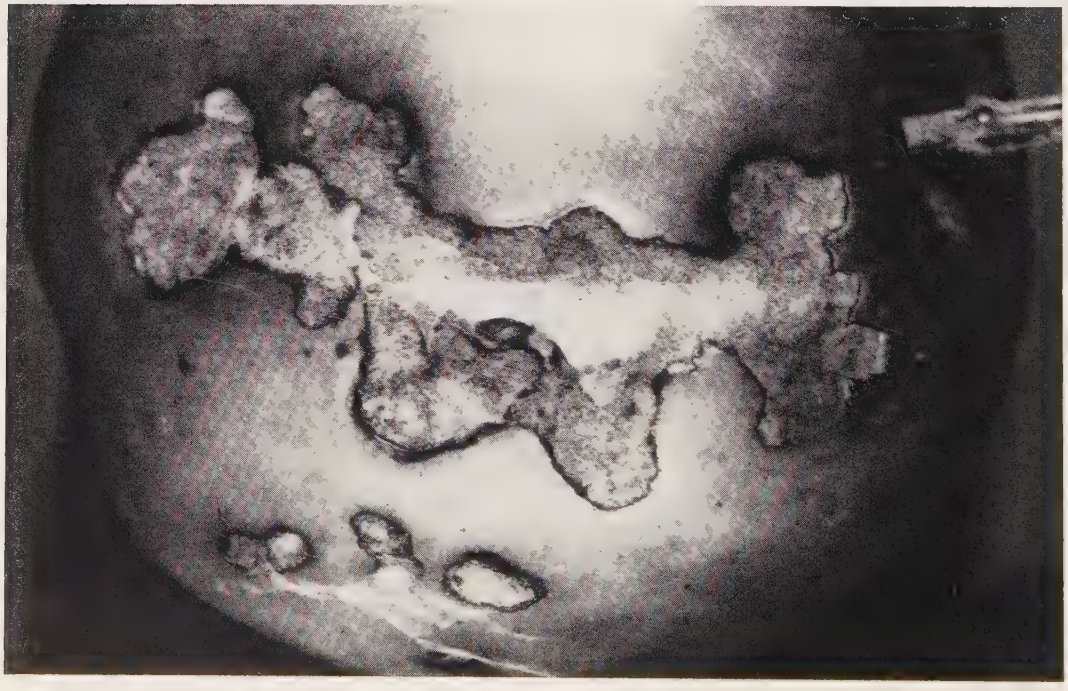

FIG. 4.
Damage to Miller's Seedling apple by larva of the summer generation (×2). Note the webbing.

on a spur, between a mummified apple and the branch, or in any similar situation. These larvae emerge and feed on the unfolding leaves in late March and April. There are normally five larval instars, and when fully fed the larvae pupate amongst the webbed leaves. The adults emerge, mate, and eggs are laid on the leaves in July. These produce the first or summer generation larvae which feed at the tips of growing shoots until late July or early August, when they may leave the shoots and feed on the fruit ; it is then that the most severe damage is caused. The larvae later pupate and the second flight of adults emerge in late August and September. The second generation eggs are laid on leaves or fruit, on which young larvae, the overwintering generation, feed until the second or third instar.

TABLE I.

DURATION, IN DAYS, OF THE VARIOUS STAGES OF THE SUMMER FRUIT TORTRICID IN THE LABORATORY.

	Number of observations.	Minimum.	Maximum.	Average.
Larval life	57	25	43	32
Pupal life	42	5	15	10
Life of adult male	8	7	10	8
Life of adult female ..	8	7	13	10
Incubation period of eggs	2,008	6	13	10

The figures shown in Table I summarize laboratory observations upon the biology of the Summer Fruit Tortricid. The number of eggs deposited by one female varied from 200 to 379 with an average of 286. They were laid in groups of from 5 to 156 eggs, the average being 40 ; the larger groups were laid by the younger females. The average length of a complete cycle in the laboratory was 56 days. The life cycle in the field, calculated from observations, is about 64 days. The development in the laboratory, where feeding conditions and temperature are more favourable, is slightly quicker than in the orchard.

As 1951 was a late season, in future years the Summer Fruit Tortricid may emerge earlier and slightly different results will probably be obtained.

Damage.

Throughout the summer the larvae may be found feeding on the leaves, but this damage, though it may cause a very slight check to the tree, is not serious (Fig. 3). It is the summer generation larvae feeding in late July and August on the fruit which are most troublesome. These larvae chew out large areas of the surface of the fruit, usually where two fruits touch or where a leaf touches a fruit, and frequently leave webbing attached to the scar (Fig. 4). As much as one quarter or more of the surface may be eaten, and the scars may be as deep as $\frac{1}{4}$ inch. The next generation of larvae, which overwinter as such, feed on the fruit in the autumn, but the scars are much shallower and smaller in area.

Hosts.

In Great Britain this insect has, with one exception, been recorded only on cultivated fruit trees. Damage has been seen on apple, cherry, myrobalan plum, pear and plum, but only in the case of apple and pear was the fruit itself attacked. Most commercial dessert and culinary apple varieties have been seen with infestations, damage to the fruit occurring on each, although it appears that in some cases the larvae prefer the leaves and do not attack the fruit itself. This, however, does not seem to be a varietal characteristic, but due to some unknown factor. In Holland (de Jong, 1951) the larvae have been recorded on many forest and hedgerow plants, soft fruits, and such plants as nettles. In this country, apart from the cultivated fruits listed above, the Summer Fruit Tortricid has only been found on a beech hedge round a fruitgrower's garden. But it should be regarded as an insect that may have as many potential host plants in England as it has on the continent.

Parasites.

Only one parasite has so far been recorded in Great Britain, this is *Trichogramma evanescens* Westwood, an egg parasite found in October 1951. This species was only common on one farm where between 5 and 10 per cent of the second generation egg batches were parasitized. Instead of developing normally the eggs turned black, and after an average of three weeks the adult parasites emerged. Though it probably attacks egg batches of the first generation also, this has not yet been observed.

Acknowledgements.

This early account could not have been as detailed but for the assistance given by many growers, members of the N.A.A.S. and others. The author thanks Mr. R. D. Eady, of the British Museum (Natural History), for naming the parasite, and Mr. J. D. Bradley of the British Museum (Natural History), for his help.

Summary.

A preliminary account is given of *Adoxophyes orana* (F.R.) (= *Capua reticulana* (Hb.)) a pest of fruit, especially apples, new to Britain.

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NOTES ON SOME INTERESTING INSECTS OBSERVED IN 1951

By A. M. MASSEE

1. Clay Coloured Weevil (*Otiorrhynchus singularis* L.).

The Clay Coloured Weevil is very prevalent throughout the growing season most years, and is particularly partial to succulent growth of the hop. The adult weevils were exceptionally common in the East Malling district during May, and were plentiful in many other parts of Kent. The weevils caused considerable harm to the young tips of hop shoots, which resulted in severe check to growth, and branching of many of the vines. The weevils also girdled the stems just above ground level, causing the stem to snap off and the leaves to wilt. Attacks of this nature, though frequent, may be very patchy, for example, a large number of hills in one area of a garden may be affected, whilst others growing nearby are uninjured.

The weevils rest by day under clods of earth, in cracks in the soil, etc. and are very difficult to find because the coloration resembles that of their surroundings. They feed at night, and when searching for them with the aid of a light it is advisable to await the early hours of the morning.

It may be noted that the Clay Coloured Weevil spends the winter in the adult state, and leaves hibernation during the first warm spring days of March and April, when the weevils may be noted sunning themselves on the tops of spile fences, gate posts, etc.

The species is parthenogenetic, the male being rarely found. Some 300 specimens collected at the end of March in a local hop garden were examined, and all proved to be females. Although at least five members of the genus *Otiorrhynchus* are associated with cultivated fruits, often causing considerable injury, especially to young trees, grafts and apple and plum stocks, the Clay Coloured Weevil is the only species found commonly in the hop garden.

2. Wasp Beetle (*Clytus arietis* L.).

The Wasp Beetle, so-called on account of its superficial resemblance to the common wasp, belongs to the family of long-horned, or wood-boring, beetles. It is a very familiar insect during the summer months, and it is frequently noted by fruitgrowers in the orchard. Considerable numbers were noted in a pear plantation at East Malling during May ; an inspection of the plantation showed that the beetles were emerging from the boughs of a number of unhealthy trees, the uniform cylindrical flight holes made by the beetles being very characteristic. The beetles were first seen on 19th May, emergence continuing until the end of the month. The larvae of the beetles were feeding within the stems of the dying and dead branches of the trees, but were not attacking the healthy limbs of the trees. Some unhealthy apple trees growing nearby were not attacked, the larvae apparently occurring only on trees which were also infected by the Shot-hole Beetle, *Anisandrus dispar* (Fab.).

Some years ago the Wasp Beetle occurred not uncommonly in a plum plantation at the Research Station ; in this instance each of the affected trees was found to be suffering from the Bacterial Die-back disease. The Wasp Beetle should not be regarded as a harmful species, but its presence in the plantation may serve as a reminder to the grower that certain trees may need due attention or removal.

3. Currant Clearwing (*Aegeria culiciformis* L.).

Very serious infestations of the Currant Clearwing have been reported from Loddington, Lynsted and Canterbury, while at East Malling it was found necessary to examine all cutting material for this pest and to reject considerable numbers. The injury caused by the larvae of this moth is apparent when pruning the bushes during the winter months. The larvae bore upwards in the pith of the shoots, causing the stems to weaken ; during pruning, affected stems readily break off at the point of entry of the larvae. At Lynsted it was estimated that 60 per cent of the shoots were tunnelled.

A bad attack of the Currant Clearwing Moth may considerably reduce the crop of an established plantation. An infested shoot or branch may appear apparently healthy until two or three weeks previous to gathering the fruit, then the weight of the crop and foliage causes the branch to snap and the fruit to wither.

The fly-like adults of the Currant Clearwing were first noted on the wing at East Malling on 12th May, and in this plantation emergence extended over several weeks.

In order to reduce infestation it is suggested that 5 per cent DDT dust be applied when the first moths are seen in the plantation. The timing of the application is made with the object of destroying the young larvae when they hatch from their eggs, which are deposited on the shoots, and before they are able to bore their way into the pith of the shoots. According to Continental entomologists the new systemic insecticides are not effective against these wood-boring insects.

4. Apple Clearwing (*Aegeria myopiformis* Bork.).

The Apple Clearwing Moth, another fly-like species closely related to the Currant Clearwing, was mentioned in these notes in 1938 and also last year. It cannot be regarded as an important pest, but may be classed as one which may prove troublesome from time to time. A very bad infestation was seen in a standard orchard of Lord Derby at Yalding, Kent, in May.

The feeding habits of the larva of the apple species differs considerably from that which infests currant ; the larva of the former feeds upon the tissue just under the bark and when the larvae are plentiful, soft blackish areas may be seen on the tree trunks, while the exudation of sap which trickles down the bark leaves a sticky mess in its trail. The amount of sap exuded varies with the variety ; Lord Derby seems to be one of the chief sufferers.

The moth is on the wing during the latter part of June and July. The ova are deposited on the tree trunks, frequently in a crack or a wound, and on hatching the larvae bore their way under the bark and produce irregular galleries in the tissue.

The larva feeds for about 20 months, and then pupates in the tissue immediately under the bark during the first half of June. The pupa is contained in a silken cocoon, and later works its way to the outer tissue of the bark, in readiness for the moth to emerge. The moths usually rest on trunks of infested trees during dull weather. The fact that the larva lives and feeds just under the bark makes control measures comparatively simple. Very efficient control can be obtained by spraying the trunks of infested trees with a 10 per cent tar oil winter wash at the latter part of May. Care must be taken to prevent the spray drifting on the leaves and branches at this period, and in grass orchards special care must be taken to prevent spray drift. It may be noted that this insect does not usually infest the limbs or small shoots of the trees, and the spray should be confined to the tree trunks.

It is usual to find odd trees attacked by this insect in various parts of Kent. Trees in gardens and in the home orchard are frequently infested ; the probable explanation being that such trees are not sprayed and receive little or no attention.

5. Apple Fruit Miner (*Argyresthia conjugella* Zell.).

The normal host plant of this Tineid Moth is the Mountain Ash or Rowan Tree, and the larva undergoes its transformations within the developing fruitlets. The association of this moth, known to fruitgrowers by the name of Apple Fruit Miner, with the cultivated apple is of considerable interest, and no less puzzling.

In most years this moth confines itself strictly to the Mountain Ash. In some seasons, however, the moth turns its attention to the cultivated apple, and locally the injury to fruit may be considerable. There seems to be a general belief that apples are only infested in seasons when there are few or no fruits on the Mountain Ash. This appears to be a likely explanation, and is supported by experience in 1932, a year in which the Mountain Ash bore few flowers. In that year severe infestations of the Apple Fruit Miner were noted in the apple orchards of the Chartham district, Kent. However, it is by no means easy to account for the prevalence of the pest in many parts of England and Scotland this season. Most enquiries have come from the North of England and from Scotland. Infested fruitlets were received from Chartham (from the same orchard where it occurred 19 years previously), Wisbech, Cambridge, Sussex, Perth and Glasgow, and on a smallholding in Sussex considerable damage was caused.

Enquiries show that the berries of Mountain Ash were plentiful during August and September, so it would seem that the presence or absence of Mountain Ash fruits does not offer the true explanation for the appearance of the insect on cultivated fruits, at least in 1951.

The species is regarded as being more plentiful in Scotland and the North of England than elsewhere in this country, but in some seasons it appears to be generally distributed, as in 1951.

Little detailed research has been made on the life-cycle and control of the Apple Fruit Miner, but one or two recent observations may be worth noting. In the South-East of England the moth may be seen in the apple orchards in June and July, where the eggs are laid on the young fruitlets. In Scotland some of the eggs are actually laid in the open flowers.

In orchards where the insect is known to be a nuisance, an arsenical or derris spray should be applied in June, care being taken to cover the fruitlets with the spray. Where sprays are being applied to control the Fruit Tree Red Spider Mite or Codling Moth no additional spray need be used.

This year the larvae of this moth were found feeding on the fruitlets of the White Beam (*Pyrus aria* Ehrh.) in September, but it is not known whether this is a normal wild host in the South-East of England.

6. Small Ermine Moth (*Yponemeuta padella malinella* Zeller).

Some 25 years ago the Small Ermine Moth was a familiar insect in apple and plum orchards throughout Kent, and the gregarious larvae living and feeding within their silken tents were abundant in fruit trees in the latter part of May and June. The advent of the tar oil winter wash changed the situation, and the moth is rarely noted in commercial orchards these days.

Before tar washes were used regularly the Small Ermine Moth was more plentiful in North Kent than elsewhere in the county, and it persisted there longer after the introduction of the tar oil washes than in other districts. The Small Ermine Moth has occurred this year in several orchards in the Swanley, Keston, Southfleet, and Maidstone districts, and the once familiar tents of the caterpillars have been conspicuous, more especially where winter washing has been omitted to save expense. The Small Ermine Moth was noted in several orchards in the Maidstone district in 1947, but was not seen again until 1951.

The sudden appearance of an insect after an absence of several years raises interesting questions, especially as the Small Ermine Moth occurs but rarely on unsprayed trees. While the strain on apples may have alternative hosts, it seems likely that some additional factor is concerned in these striking fluctuations.

7. Pear Sawfly (*Hoplocampa brevis* Klug).

The pear plantations at Hoo, near Rochester, Kent, where the outbreak of the Pear Sawfly was discovered two seasons ago, were inspected several times during the blossom period, and intensive search made for the adult sawflies, but none were found.

The fact that Pear Sawfly could not be found in any of the plantations known to be infested the previous two seasons, was indeed encouraging ; it suggested that the drastic control measures carried out in the years 1949 and 1950 had eradicated the pest. The insecticide used was 0·01 per cent parathion, applied at petal-fall when the first larvae were seen to hatch out, together with a second application a few days later. It seems too much to hope that the pest has been completely eliminated from these orchards, but the prospects of adequate control are good.

A standard Conference pear orchard, situated about two miles from the original infestation at Hoo, where the second small outbreak was first noted, was visited again during the blossom period. After diligent search three adult sawflies were found in the blossoms. No more sawflies were found on subsequent visits, and there was no evidence to suggest that the insect was establishing itself. It was decided to spray this plantation with 1 lb. BHC (50 per cent wettable powder), water 100 gallons, plus wetter ; this insecticide was selected because the grower preferrred not to use a phosphorus insecticide on his fruit. It is not known how the Pear Sawfly reached this orchard, where it was first found on a few trees last year. The adult sawfly is able to fly quite readily, and does so during warm, sunny periods ; but it seems unlikely that the insect came from the original infestation at Hoo which was confined to the pear plantations of one farm only.

Finally, it should be noted that the larvae of the Apple Sawfly are able to survive in the soil for two seasons ; although it is not known whether the pear species has the same habits, it will be necessary to watch the orchard at Hoo very carefully, and see if the insect appears during the blossom period next season.

8. Dock Sawfly (*Ametastegia glabrata* Fall.).

Numerous reports and observations show that the Dock Sawfly has been causing damage to apple fruits in various parts of the country ; enquiries have been received from Cambridgeshire, Wisbech, Suffolk, Somerset and Kent. The injury to Allington Pippins in an orchard at Yalding proved very considerable. A limited amount of damage is caused by this insect every year, but the last serious outbreak occurred in 1936 and was mentioned in these notes.

The normal host plants of the Dock Sawfly belong to the genus *Rumex*, including the common dock. The injury is made by the mature larvae of the second and, in some seasons, of the third generation which tunnel in the flesh of the apples.

A brief outline of the life-cycle of the insect is as follows : There are normally two generations in a year, but in some seasons there may be three. The larvae feed on the foliage of docks, and on reaching maturity they seek a suitable situation in which to hibernate. For this purpose they often seek out the pithy stems of various plants, particularly various species of *Rubus* and the dead hollow stems of docks. The trouble occurs in orchards where docks abound within the orchards and adjoining

hedgerows. The Dock Sawfly larvae feed on the leaves of the plants and when fully fed seek quarters in which to hibernate. Very frequently these larvae crawl up the tree trunks and enter the fruits still hanging on the trees during September and October. The hole made by the larva is a small, cylindrical tunnel, usually straight, and an inch or more deep, rather like that produced by piercing the fruit surface with a small, round knitting needle. Sometimes the tunnel is curved but this is exceptional. When the larvae are numerous several may enter the same fruit.

The irony of this type of damage is the fact that once the larvae completes the tunnel, it finds the cavity unsuited for hibernating in and leaves again almost immediately. Indeed one rarely finds apples with larvae still inside the tunnel. However, once the fruit surface has been broken, the damage has been done and Brown Rot or other fungal diseases gain access.

As a means of prevention docks should be eliminated and the stems of standard trees should be grease banded. In bush orchards the docks should be cut down before the larvae of the second generation start feeding on the plants.

9. Shield Bug (*Sehirus bicolor* L.).

It is curious that the common White and Black Shield Bug, a species of Hemipteron, which is usually associated with Woundwort and Dead Nettle, should sometimes occur on cultivated fruits. Several adult specimens were found on Bramley's Seedling in June ; they were not feeding on the foliage, but a number of egg batches were found on the upper surface of the leaves. The small, spherical, green eggs were laid in batches of 9 and 13. The nymphs began to emerge from one egg batch on 18th June and from another on the 21st of the month. All the newly hatched bugs quickly dispersed, and were not observed feeding.

Adults of the same species also occurred on raspberry foliage in a plantation adjacent to the above orchard. The bugs were very numerous, and they were not observed feeding on the foliage. The host plants of the bugs were not present amongst the raspberries or in the adjoining hedgerows.

This species was also recorded on apple in 1936, but in that year it was not so common.

10. Mullein Leaf Bug (*Campylomma verbasci* M.-D.).

The Mullein Leaf Bug, a species of Mirid or Capsid Bug, was first recorded as a British insect in 1938. It is also well-known in Canada where it is known by two popular names, The Mullein Leaf Bug and the False Tarnished Plant Bug. In the latter country it has been described as a minor pest of both apple and pear, and several papers describing the bionomics of the insect have been published.

The Mullein Leaf Bug has been recorded in this country from Middlesex, Essex and Kent, associated with hollyhock, mullein and potato. It was collected on apple foliage at East Malling in June, 1940, and at Great Braxted, Essex, in August, 1948. There is no evidence to suggest that the species is harmful to apple in this country.

It is probable that this Mirid Bug is widely distributed in the South-East of England. It is distinguished by its small size and pale colour.

11. Plum and Apple Leafhoppers (*Typhlocyba spp.*).

A number of species of leafhoppers occur on plum, damson and apple, and the characteristic mottling of the leaf upper surfaces is caused by the feeding of these insects during the summer months. These Hemiptera have been known to infest fruits for very many years, but the species concerned, their bionomics and their role in the economy of the orchard have not been studied in detail as yet. In the past few years these insects have been much more prevalent in our fruit plantations, but whether their increase is associated with the use of some of the new insecticides is not known. Severe infestations were noted at Sutton Valence, Ulcombe and East Sutton ; one fruitgrower stated that he considered the damage caused by these insects to equal that done by the Fruit Tree Red Spider Mite. At East Sutton the infestation was confined to damsons ; in one plantation the damage was serious. The species causing the damage, *Typhlocyba quercus* F., was very active, white in colour, and the wings marbled with red. It caused very extensive leaf mottling, while many of the trees were defoliated prematurely. Exudations caused the leaves to become sticky, and this was followed by a growth of sooty mould, which caused the foliage remaining on the trees to turn blackish, and of a harsh, brittle texture. A few adult leafhoppers were still present on the trees during the third week of October.

The leafhopper found damaging apple foliage at Sutton Valence was *Typhlocyba froggatti* Baker, a pale buff coloured species which is frequent on apple. The injury caused to apple was very similar to the damage to plum described above.

Other species of leafhoppers were also unusually common on various kinds of fruit trees in the county and it is probable, as with many other fruit insects, that the leafhoppers have their peak

seasons, during which considerable injury may be caused to the trees. The group as a whole is worthy of more attention, especially as at least one species is regarded as a possible vector of a top fruit virus on the Continent.

12. Pear Sucker (*Psylla pyri* L.).

In some localities the Pear Sucker has been abnormally abundant, and has been regarded as the cause of the failure of some of the pear crops. It is curious that these enquiries always emanate from the same parts of Kent, namely, the Dartford, Cliffe, Hoo and Rochester districts where Pear Sucker was prevalent 30 years ago.

When plentiful, the immature suckers emit sticky secretions on the foliage, followed by a sooty fungal growth, which blackens the leaves, and causes premature defoliation. The fruit drop may be considerable, and the fruits remaining on the trees are often undersized and misshapen.

The infestation early in the season may be quite small and cause little harm, but the three generations allow the insect to build up, and by the date of the third generation the population may well reach epidemic proportions. The Pear Sucker overwinters in the adult state, sometimes on the trees, but also in the hedgerow, amongst ivy growing on walls and buildings, or in other suitable situations. This presents a difficult problem when control measures are being considered. A tar oil wash will destroy those insects hibernating on the tree, but the remainder escape. It is considered more economical, therefore, to omit the winter wash, and delay any treatment until the spring, and then apply one of the new insecticides to destroy the nymphs of the first generation.

13. Woolly Aphid (*Eriosoma lanigerum* Haus.).

In North America, Australia, New Zealand and elsewhere the Woolly Aphid normally spends part of its life-cycle feeding on the shoots and branches, and then descends and establishes itself on the roots of the trees. In this country, however, the insect rarely feeds on roots, and the entire life-cycle is spent on the aerial part of the tree. Small colonies of aphids do occur, however, on superficial roots or those brought to the surface by mechanical implements.

It is interesting, therefore, to record the presence of large colonies of woolly aphids feeding on the roots of Malling IX rootstock in a private garden at Leybourne, Kent. The colonies were found about 12 inches below the soil surface, and some of the galls produced measured half to one inch in diameter. It was not known how long the aphids had been feeding on the roots, but judging by the size of the galls the period must have been many months.

A very severe infestation of Woolly Aphids also occurred in an established orchard of Cox's Orange Pippin near Chelmsford, Essex, which had been sprayed twice after the blossom period with HETP, with the intention of controlling the Fruit Tree Red Spider Mite. By the third week of September the populations of both Woolly Aphid and of mites were abnormally high, however.

The Woolly Aphid has presented a problem in many Kentish orchards for years, but during the past few seasons it has been more prevalent than usual, both in the established orchard and the nursery beds. There is a general belief among fruitgrowers that the Woolly Aphid presents a more serious problem in orchards where some of the new insecticides are used regularly. This supposition may prove correct, but at present there is no evidence to support this belief, and more work is needed on the subject. It is probable that the Woolly Aphid parasite may be adversely affected when synthetic and phosphorus insecticides are used in apple orchards after the blossom period, and some evidence is available to this effect.

14. Hop Damson Aphid (*Phorodon humuli* Schr.).

It is not unusual for the Hop Damson Aphid to hatch early in the season, and this phenomenon has been reported on a number of occasions. Observations at Tonbridge showed that the insect was hatching exceptionally early in the year, the first record being made on 17th February; judging by the number of nymphs seen on the shoots, hatching must have started even earlier. Hatching was also noted on sloe and damson bushes at East Malling. It is not possible to give the reason for this early emergence, since the bushes were still dormant and remained so for some time. It may be noted that the hatching period of this insect may extend over a fairly long period, up to five or six weeks, as was the case in 1951.

15. Apple Leaf Gall Mite (*Phyllocoptes schlechtendali* Nal.).

The apple Leaf Gall Mite is so small that it is not visible to the naked eye, and can only be detected with a hand lens with difficulty. This minute animal lives, amongst the hairs, on the under surfaces of the leaves during the summer months, and hibernates under the bud scales during

the winter time. It is much more abundant on apple than generally supposed, but doubtless it is frequently overlooked.

Leaves damaged by this mite were received from Wisbech in October. The grower stated that only dessert varieties appeared to be attacked, and on some trees the injury was extensive. The mites feed on the undersides of the leaves, producing small, brown, raised areas, which give the leaf the appearance of having been attacked by one of the rust fungi, the colour turns a dull brown, and the surface is crinkled. The upper surface of the leaf may be affected also, and badly attacked leaves are small and malformed.

This mite is usually harmless in orchards where the lime-sulphur schedule is followed for scab control, but in the event of a sulphur shortage this mite may become more plentiful again. It occurs commonly in the cider orchards of the West Country to-day.

16. Black Currant Gall Mite (*Phytoptus ribis* (Westw.) Nal.).

It is evident that this mite is increasing again in many plantations, and that reversion is followed in its wake. Very bad attacks of big bud were reported in blackcurrant plantations at Blean and Chartham, near Canterbury, and in both cases the percentage of reverted bushes was very high. It was disturbing to find bad infestations of big bud in the Maidstone district this spring.

Some years ago the advice given to growers was to spray the bushes with 8 per cent lime-sulphur when the leaves were the size of a two shilling piece. Later this was modified, and the application was made at the same strength at the " grape stage " of flower development. Since the advent of the many sulphur shy varieties the formula has been modified yet again, and the present recommendation is that sulphur tolerant varieties should be sprayed with 4 per cent lime-sulphur at or just prior to the grape stage on a warm day, in the absence of cold winds. Sulphur shy varieties should be sprayed at a strength not greater than 2 per cent. Suitable weather conditions are, of course, very important when sulphur shy varieties are sprayed with lime-sulphur. The use of more modern insecticides requires investigation.

One of the chief reasons for the increase of the Black Currant Gall Mite at the present time may be due to the lack of routine applications of the spray each year. In former years the spray used to be applied every year until the plantation was grubbed, the idea being to prevent the mite becoming established.

17. Fruit Tree Red Spider Mite (*Metatetranychus ulmi* Koch).

So much has been published concerning the Fruit Tree Red Spider Mite that it is not proposed to discuss the subject at length in these notes. One or two observations may be of interest, however.

The mite has been recorded on a very large number of host plants, including many of the top and soft fruits grown in the country. It has occurred on sweet and sour cherries for many years, but during the past two or three seasons it has become more prevalent on them. During the year bad attacks have been noted in cherry orchards at Rainham, Sittingbourne and East Malling. The symptoms are similar to those on other fruits, save that discoloration of the foliage is apparent earlier in the season. It is not known whether some particular strain of the mite has adapted itself to feeding on cherry, but it is evident that the mite thrives equally well as on other hosts.

It is disturbing to find that the orchards at Rainham, Sittingbourne and East Malling, where the mite populations were high during the summer, are now carrying considerable populations of winter eggs. In these circumstances it seems that the mite has added cherry to its list of regular host plants, at least in some parts of Kent.

18. Bird damage.

Destruction by birds of the buds of many kinds of cultivated fruits has presented a very serious problem in many fruitgrowing districts of Kent. The birds chiefly responsible are tits, bullfinches, chaffinches, and to a lesser extent, sparrows.

Bird attacks have been reported from Brenchley, Canterbury, Cranbrook, and East Malling. At Canterbury chaffinches destroyed the buds of Morello cherries and gooseberries, causing considerable damage. At East Malling chaffinches stripped the buds from a long row of damsons, and then attacked apple buds in an adjoining plantation. This type of damage was first seen during the third week of December, and continued on and off until March. Various measures used to scare the birds away proved of little use. At flowering time it was found that all the potential flower buds of the damsons had been destroyed by the birds. A number of apple trees had the flower buds removed also, but the damage was less severe in this orchard.

Sparrows were responsible for damage caused to cherries at Cranbrook, while at Brenchley, bullfinches and chaffinches were responsible. A number of fruitgrowers have tried the old fashioned

method spraying the trees with a solution of alum as soon as the birds start to visit the trees. The formula tried is as follows : alum 3 lb., water 100 gallons. This treatment will not cause any harm to the trees, and is claimed by some to be effective for a period of about five weeks.

Summary.

Short notes are given of some 18 interesting insects and mites found on fruit during 1951. Among those mentioned are the Apple and Currant Clearwing Moths, the Apple Fruit Miner, the Pear Sawfly, the Dock Sawfly and the Pear Sucker. The Mullein Leaf Bug which occurs on apple and other hosts is also referred to briefly.

TRANSMISSION OF REVERSION OF BLACK CURRANTS

By A. M. MASSEE

Introduction.

In 1921 experiments were initiated to determine whether the Black Currant Gall Mite, *Phytoptus ribis* (Westw.) Nalepa (Massee, 1928) was a vector of Reversion of black currants, Ribis Virus I (Smith, 1937). The results were very suggestive, but not conclusive (Amos, *et al.*, 1927a), and at the suggestion of the late Mr. Jesse Amos it was decided to carry out further experiments when possible.

Material.

Healthy bushes. In the summer of 1939 a number of black currant bushes, of the variety Baldwin, were selected from a fruiting plantation at the Research Station. In the winter of 1939-40 the bushes were pruned to within two to three inches of ground level, to provide shoots suitable for planting as cuttings. During the summer of 1940 they were inspected at regular intervals and any plants exhibiting abnormal foliage were removed and destroyed. Later that year cuttings were taken from the healthy bushes remaining, those from each bush being labelled and planted separately. In the summer of 1941 the maiden plants were rogued from time to time and all suspicious or unhealthy plants removed. The parent plants were also retained, although no cuttings were taken from them ; they were examined periodically, and any suspicious bushes removed. The cuttings from the unhealthy bushes were also destroyed, whether they exhibited disease symptoms or not.

In the autumn of 1941 cuttings were taken from selected maiden plants of the series referred to above and were grown in the nursery until the winter of 1942-3. They were inspected several times during the summer of 1942 and a certificate was obtained under the Scheme for the Certification of Black Currants, indicating the complete absence of any apparent symptoms of Reversion.

Reverted bushes. Six three-year-old bushes of Baldwin, manifesting typical symptoms of Reversion and of Big Bud, obtained from a private garden at Wateringbury, Kent, were transplanted to 8-inch pots, and placed in the insectary during the winter of 1942-3.

Mites. The Black Currant Gall Mites used in the transmission experiments were obtained from the same source as the reverted bushes.

Methods.

Thirty bushes of Baldwin, selected for their uniform size and vigour from the healthy material described above, were planted in 8-inch pots in November 1942 and transferred to the insectary. Twenty-four plants were selected for the direct inoculation experiment, while the six remaining plants were housed in a separate compartment of the insectary to serve as untreated controls. The six reverted plants were placed in the same compartment as the plants of the inoculated series.

All bushes, save the reverted plants, received a 5 per cent tar oil wash in January, 1943, 1944 and 1945. The 24 plants of the inoculated series did not receive any other spray treatment. The six controls, however, were sprayed with 3 per cent lime-sulphur at the end of March each year. These plants were also dusted with flowers of sulphur and nicotine from time to time during the summer months. Each plant was lightly pruned in the winter of 1943-4 and again in 1944-5. In addition, all bushes received a top dressing of rich new soil each winter, and a dressing of fish guano each spring to encourage new growth.

The direct transfer of mites.

The first transfer of mites was made in December, 1942, 40 mites being placed on each of 12 buds of each plant. In addition cut-up portions of Big Buds removed from the reverted plants were placed in the axils of 12 buds of each plant, and others were placed on top of the soil. Similar inoculations were made monthly until April, 1943. They were started again in November, 1943, and continued until the following April. More mites were transferred monthly during the winter of 1944-5. A total of 2,400 mites were transferred to each of the inoculated plants each year.

Results.

The observations made upon the bushes inoculated with mites are summarized in Table I.

Colonies of mites were established on all the inoculated plants during the first year, but the number of Big Buds recorded per plant varied considerably. On one plant only two Big Buds were recorded as against 30 on the most severely infested bush.

The fact that all the plants were colonized with mites in such a short time may be regarded as important, since one of the difficulties in this kind of experiment is to get colonies established artificially. For example, in the earlier work it was not possible to establish mite colonies on every plant.

It will be noted that the number of Big Buds did not increase materially per plant during the second and third year of the investigation. This is probably due to the fact that the bushes were regulated by light pruning each winter, and some of the shoots carrying them were removed.

Further, the fact that some of the bushes exhibited very few or no Big Buds during the third year, i.e. No. 21, does not necessarily mean that they were carrying a very low mite population, since mites are frequently present in buds which are normal in outward appearance (Massee, 1927b). An examination of some of the apparently normal buds of bushes Nos. 9, 12 and 21 showed that they contained mites.

TABLE I.

NUMBER OF BIG BUDS FORMED ON INOCULATED BUSHES.

Bush number.	Number of Big Buds.		
	10th November, 1943	27th March, 1944.	19th March, 1945.
1	10	7	8
2	4	4	3
3	9	8	9
4	8	4	12
5	12	7	14
6	10	10	8
7	12	5	11
8	13	7	7
9	6	0	2
10	21	10	8
11	4	3	12
12	4	4	7
13	2	1	12
14	22	11	5
15	11	7	5
16	30	18	6
17	23	5	8
18	13	8	18
19	7	6	3
20	5	5	8
21	2	1	0
22	10	7	6
23	7	4	6
24	7	3	9

The same method as used in the past, viz. a system of numerals and letters, has been followed in estimating the amount and intensity of Reversion exhibited by a bush. The numerals represent the numbers of fifths of the bush which is affected, and the lettering the intensity of the symptoms. A, B, C, D and E represent increasing degrees of abnormality, the last being the extreme. This notation is adopted in Table II.

It will be seen that 10 plants showed mild or moderate symptoms of Reversion in 1943. No plant exhibited severe symptoms of Reversion and 14 plants were still quite healthy.

The year following nine plants exhibited definite Reversion symptoms, one less than in 1943. Of the remainder, eight were still quite healthy, and seven were regarded as suspicious, though definite Reversion symptoms were not noted. Of the latter four were recorded as exhibiting mild Reversion symptoms in 1943. Plants Nos. 8 and 17 were showing severe symptoms of Reversion.

By the latter part of June, 1945, all the plants showed definite Reversion symptoms, and of these 10 were placed in category E, which denotes the extreme symptoms of Reversion. Five bushes exhibited a moderate degree and intensity of Reversion, and the remaining nine, while showing definite Reversion symptoms, were regarded as mild examples.

A comparison of Tables I and II shows there is no clear relation between the number of Big Buds per bush and the intensity of the symptoms. For example, on bush No. 9 very few Big Buds were recorded, but in the third year of the experiment the bush was completely reverted with severe malformation of the foliage. On the other hand Big Buds were numerous on bushes 7 and 11, but in

each case less than half the bush was showing symptoms of Reversion in 1945 and in neither case were the symptoms severe.

It should be pointed out that while large numbers of mites were transferred to all the inoculated plants each year, there is no means of determining how many of these became established ; and this may account in some part for the variation of the degree and intensity of Reversion in the bushes of the inoculated series.

The six control plants (selected from the same material as those of the inoculated series) remained healthy and vigorous throughout the experiment. None of the bushes developed Big Buds or showed symptoms of Reversion. A number of buds were removed from each bush from time to time and examined for the presence of mites, but none were found.

The results of the experimental infection of normal plants with Black Currant Gall Mites obtained from reverted bushes indicate quite clearly that there is some relationship between mite infestation and Reversion. Each of the 24 bushes inoculated with mites from reverted bushes exhibited symptoms of Reversion by the third year or earlier, while none of the control plants showed Reversion

TABLE II.

REVERSION IN INOCULATED BUSHES.

Bush number.	Degree and intensity of Reversion.		
	23rd July, 1943.	13th August, 1944.	27th June, 1945.
1	nil	nil	3E
2	nil	1C	2E
3	1A	nil*	5E
4	nil	1C	5E
5	1B	1C	4E
6	nil	nil	3E
7	2B	nil*	2C
8	1B	4E	4D
9	nil	nil*	5E
10	nil	nil*	4E
11	nil	nil	2C
12	nil	nil	2C
13	nil	nil*	2D
14	nil	nil	1D
15	nil	nil	3B
16	2C	nil*	4E
17	4C	4D	4E
18	nil	1C	3C
19	nil	nil	1D
20	1A	3C	2D
21	1A	3C	3C
22	nil	nil	3C
23	1A	1C	1C
24	2C	nil*	3C

* Bush unhealthy, but Reversion symptoms not diagnosed.

symptoms or developed Big Buds. It can be concluded, therefore, that the Black Currant Gall Mite can be regarded as a vector of Reversion.

One important aspect of this investigation concerned the transfer of mites from reverted to healthy plants. Colonies of mites were established on each bush inoculated during the first year—and this fact largely accounts for the results obtained in the experiment. In practice it is often very difficult, if not impossible, to make successful transfers of mites from one plant to another, in view of the very delicate nature of the animals concerned.

Other insects tested.

A capsid bug and four species of aphids were also tested as possible vectors of Reversion.

These preliminary tests were carried out in 1943, 1944 and 1945.

Eight healthy plants of Baldwin, selected from the same material as used in the direct mite transmission experiment, were used for each of the five insects to be tested, of which two plants were kept as controls in each case.

The following insects were used :

The Currant Capsid Bug, *Lygus pabulinus* (L.)
The Red Currant Aphid, *Cryptomyzus ribis* (L.)
The Lettuce Aphid, *Nasonovia ribis-nigri* (Mosley)
The Gooseberry Aphid, *Aphis grossulariae* Kltb.
The Currant-Lettuce Aphid, *Hyperomyzus lactucae* (L.)

These species were bred in numbers on reverted plants, also obtained from the garden at Wateringbury, Kent, and later 40 insects in various stages were transferred to each of the healthy plants housed in separate compartments of the insectary.

Later it was observed that each of the inoculated plants exhibited direct insect damage during the summer months, but none of the inoculated plants showed virus symptoms during the first, second or third year of the experiment.

The control plants, which were not inoculated with insects, remained healthy throughout the investigation.

As a result of this preliminary trial there is no evidence to suggest that the Currant Capsid Bug or any of the four species of aphids tested are vectors of Reversion of black currants.

Acknowledgements.

The writer wishes to acknowledge the help given by the late Mr. Jesse Amos in selecting suitable plant material for the investigation, his keen interest during the first two years of the experiment, and his assistance in recording the virus symptoms presented in Table II for the years 1943 and 1944.

The writer is also indebted to Dr. R. V. Harris and Mr. A. F. Posnette for reading the manuscript and making valuable suggestions. Acknowledgements are also made to Mr. R. J. Garner for raising the experimental material.

Summary.

Each of 24 normal black currant bushes, artificially infected with Black Currant Gall Mites obtained from reverted bushes, developed symptoms of virus disease in three years or sooner.

All of the six untreated control plants remained apparently normal throughout the experiment.

Similarly attempted artificial transmissions by means of the Currant Capsid Bug and four species of currant aphids gave negative results.

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STUDIES IN POPULATION FLUCTUATIONS OF THE STRAWBERRY APHID, *PENTATRICHOPUS FRAGAEFOLII* (COCK.)

I. ENEMIES OF THE STRAWBERRY APHID

By G. H. L. DICKER

Introduction.

Natural fluctuations in aphid populations can usually be attributed to one or more of four main causes ; the action of parasites and predators, physiological changes within the host plant, the arrival or departure of winged forms, and climatic conditions. Often, in the field, the effect of individual factors cannot easily be assessed due to the interaction of others, and further difficulties are encountered by the inability of the investigator to remove or minimize the effect of certain factors whilst studying the action or interaction of others. It is, for example, normally impossible on a field scale, without disturbing or affecting the resident population, to prevent attacks by parasites or the influx of alatae from outside sources which may mask changes due to other causes.

It is generally agreed that parasites and predators are of considerable importance in influencing population changes during the summer months, though in connection with the Strawberry Aphid Dicker (1952) has suggested that the primary cause may be intimately connected with the host rather than due to external factors. This species would appear to be well suited to a study of the effects due to the host as parasitism, apart from sporadic attacks by entomophagous fungi, is almost unknown, a very limited number of predatory insects occur regularly, only a small percentage of the population develop into alate viviparae and these during a short and well defined period and, finally, the normal seasonal changes in population follow a regular pattern.

During biological studies on the Strawberry Aphid in the main fruit growing areas between 1943 and 1946 and subsequently in Kent, notes were made on the incidence of parasites and predators and the species observed are enumerated below.

Parasites.

Hymenoptera.

Aphidiidae	*Aphidius* sp.
Eulophidae	*Aphelinus asychis* Walk.

Fungi.

Empusa planchoniana (Cornu) Petch.

The Strawberry Aphid is remarkably free from attacks by insect parasites ; none are recorded and during the past nine years very few parasitized aphids have been seen ; from these an undetermined species of *Aphidius* and *Aphelinus asychis* have been bred. Only eight specimens attacked by the former and four by the latter have been observed since 1943 in areas as widely separated as Kent, Worcestershire and the Isle of Ely.

Fungal infection is noted much more frequently, usually between May and July, but occasionally also from October to December. The intensity of attack varies greatly and is probably governed to a large extent by climatic conditions, though in many strawberry beds the aphids show no sign of infection throughout the year. Thomas and Jacob (1940) reported severe infection, probably by *Empusa* sp., in North Wales and Wood (1950) considered *E. planchoniana* mainly responsible for the summer decline in populations noted annually in the same area. Isolation of the primary parasite is often difficult due to the rapidity of secondary infection and this may account for the presence of *Cephalosporium aphidicola* Petch recorded by Petch (1942).

Predators.

Hemiptera-Heteroptera.

Anthocoridae	*Anthocoris nemoralis* (F.)
	A. nemorum (L.)
	Orius niger (Wolff)
	O. majusculus (Reut.)
	O. laevigatus (Fieb.)
Miridae	*Deraeocoris ruber* (L.)
	Plagiognathus arbustorum (F.)

Neuroptera.	
Chrysopidae	*Chrysopa carnea* Steph.
Coleoptera.	
Staphylinidae	*Tachyporus hypnorum* (F.)
	T. obtusus (L.)
Coccinellidae	*Rhyzobius litura* (F.)
	Adalia bipunctata (L.)
	Coccinella septempunctata L.
Diptera.	
Syrphidae	
Acarina.	
Anystidae	*Anystis agilis* Banks
Trombidiidae	*Allothrombium fuliginosum* Herm.

Anthocoris nemorum is the commonest species of Anthocoridae found on strawberry although numbers are never very high ; in routine counts of aphids by taking one unfolding leaf from a plant as the sample unit the frequency of appearance rarely exceeds one specimen on every tenth leaf and is usually considerably less. Over-wintered adults of *Anthocoris* spp. are seldom seen, nymphs appear in May, mature in June or July and the second generation is present until October. Adults of *Orius majusculus* and *O. laevigatus* sometimes appear in July, followed by nymphs of the second generation until September ; *O. niger* is normally present only as scattered adults during the autumn and winter months.

Single nymphs of *Plagiognathus arbustorum* and *Deraeocoris ruber* occur from May until July.

Larvae of *Tachyporus* spp. are among the commonest of predatory insects (Dicker, 1944) ; the first are seen about mid-May, maximum numbers occur in June and the last reach maturity in August. Small numbers of adults are found on strawberry plants throughout the year.

The other species of insects are of infrequent occurrence. From neuropterous larvae only *Chrysopa carnea* has been bred through to the adult stage. Syrphid larvae have been observed only occasionally by the writer although Thomas and Jacob (1940) report a considerable reduction in aphid numbers due to these insects. Single adults and larvae of *Adalia bipunctata* and *Coccinella septempunctata* are present during the late spring and summer and larvae of *Rhyzobius litura* are sometimes found living on the undersides of the leaves from May until July.

The two acari, *Anystis agilis* and *Allothrombium fuliginosum*, are generally present on strawberry plants in small numbers.

Discussion.

From observations extending over several years there is no evidence that the Strawberry Aphid is attacked by insect parasites except on very rare occasions. Fungal infection, on the other hand, may be severe and usually coincides with warm, humid conditions, although temperature would not appear to be the most important controlling factor as outbreaks are sometimes observed during the late autumn. As a supplementary measure, fungal parasites are at times of considerable importance in reducing aphid populations, but the irregularity in time and intensity of outbreaks makes it very unlikely that this is a factor of primary importance in causing the marked seasonal variations in population observed annually in the field.

The majority of the predators listed are found in such small numbers that even their combined effect on the normal aphid population can only be slight. Members of two genera, *Anthocoris* and *Tachyporus*, do, however, occur with sufficient regularity to merit more serious consideration of their importance in causing the summer decline in population, but all efforts to obtain any correlation between host and predator populations have so far failed. In addition to those listed there are undoubtedly other insects which occasionally prey on the Strawberry Aphid, including adults of the Carabidae and Cantharidae among the Coleoptera. The former, being mainly nocturnal in habit, have not been observed attacking the Strawberry Aphid in the field, but will do so in captivity ; on single occasions adults of *Cantharis rustica* Fall. and *Rhagonycha fulva* (Scop.) have each been observed feeding on the aphid.

Acknowledgements.

The author gratefully acknowledges help from Mr. G. E. J. Nixon and Mr. G. J. Kerrich of the Commonwealth Institute of Entomology who kindly named the parasites.

Summary.

The Strawberry Aphid, *Pentatrichopus fragaefolii* (Cock.) is on rare occasions parasitized by *Aphidius* sp. and *Aphelinus asychis* Walk., more frequently by the fungus *Empusa planchoniana* (Cornu) Petch. Among 16 insects and mites listed as predators only *Anthocoris nemorum* (L.), *Tachyporus hypnorum* (F.) and *T. obtusus* (L.) occur regularly on Strawberry.

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RESULTS OF SOME EXPERIMENTS TO CONTROL WINTER MOTH AND TORTRICID LARVAE ON APPLE

By G. H. L. DICKER and J. B. BRIGGS

Since 1948 field trials have been carried out annually to study the effect of winter washes and insecticides applied with the green cluster lime-sulphur spray against larvae of the Winter Moth, *Operophtera brumata* (L.), and the various species of Tortricids which occur on apple. The experimental plots have, unfortunately, always been lightly infested, but sufficient data have been accumulated to draw general conclusions and, as more detailed studies are now being undertaken, it seems opportune to present the results already obtained.

Field Trials.

In 1948 a trial was carried out in collaboration with Horticultural Officers of the Kent W.A.E.C. at Weald View, Ulcombe; the sprays tested are shown in Table I. The orchard contained half standard trees of Bramley's Seedling; each treatment was replicated three times and applied to randomized blocks containing 24 trees. From each of the four centre trees a sample of 400 trusses, sub-divided into units of 100 from the north, east, south and west sides, was inspected and any larvae present were recorded. A truss represents the rosette leaves and blossom buds arising from a fruit bud; where fruit buds were sparse, the leaves from vegetative buds were also included, provided the leaf area was as great as that from fruit buds. All trees received a 5 per cent tar oil wash in January.

In 1949 and 1950 trials took place at East Malling on the variety Lane's Prince Albert, the sprays tested being listed in Table II. Again each treatment was thrice replicated among randomized blocks. Samples of 200 trusses, sub-divided into units of 50, were inspected from each of four trees in 1949 and each of five trees in 1950 from each block.

A similar trial in 1951 proved abortive due to the very low level of infestation.

In all cases commercial formulations of the spray materials were used. In 1949 the DNC-petroleum concentrate contained 1·8 per cent dinitro-*ortho*-cresol and approximately 70 per cent mineral oil; in 1950 the concentration of dinitro-*ortho*-cresol was increased to 2·4 per cent. The DDT was a wettable powder with china clay as diluent and the parathion a dispersible liquid.

The normal fungicide programme of $2\frac{1}{2}$ per cent lime-sulphur at the green cluster stage and 2 per cent at pink bud was applied to all trees except in 1948, when certain blocks received either phenyl mercury chloride or wettable sulphur. All the insecticides used at the green cluster stage were applied in combination with the appropriate fungicide. Results were assessed during the late pink bud or early blossom period.

Biological notes.

Detailed information on the hatching period of *O. brumata* eggs is not at present available. Observations on the trial trees and, in 1950, on potted trees bearing many eggs, indicated that hatching began when the buds reached the breaking stage, in the latter half of March, and most eggs had hatched within 10 days. Young larvae burrow into the fruit buds and remain hidden until the green cluster stage when the rosette leaves and blossom buds separate. Subsequently they may be found inside blossom buds or among loosely webbed leaves.

Adults reared from larvae collected from the treated and control trees indicated that *Cacoecia oporana* (L.) (=*podana* (Scop.)) and *Spilonota ocellana* (Schiff.) were the two most common species of Tortricids, the former being more abundant. Small numbers of the following species were also reared: *Cacoecia crataegana* (Hueb.), *C. xylosteana* (L.), *C. lecheana* (L.), *Pandemis cerasana* (Hueb.), *Argyroploce nubiferana* (Haw.) (= *variegana* (Hueb.)) and, in 1951, one specimen of *Adoxophyes orana* (F.R.).

Discussion of results.

Winter Moth larvae.

Since the treatments used in 1948 (Table I) were not repeated in subsequent years, no very definite conclusions can be drawn from these results. The relatively low kill of eggs obtained with 7 per cent petroleum should be treated with caution as it is not in accord with laboratory tests made

by Shaw and Steer (1947) ; nor does it approach the figure obtained with considerably lower concentrations of petroleum containing dinitro-*ortho*-cresol in 1949 and 1950, though in these later trials the improved performance may be due to dinitro-*ortho*-cresol, as Bennett, Kearns, Martin and Wain (1946) have demonstrated the marked ovicidal properties of this material against Winter Moth eggs. The 1948 trial was the only one in which any effect was observed due to the addition of DDT to the winter wash.

TABLE I.

1948 SPRAYING TRIAL, ULCOMBE.

Treatment.	Date applied.	Percentage reduction.	
		Winter Moth.	Tortricids.
Control	—	0	0
7% petroleum	11th March	38	82
7% petroleum + 0·1% DDT	,,	91	84
7% petroleum + 0·1% DDT	,,	100	96
0·1% DDT	5th April		
0·1% DDT	,,	79	77

TABLE II.

1949-50 SPRAYING TRIALS, EAST MALLING.

Treatment.	1949.			1950.		
	Date applied.	Percentage reduction.		Date applied.	Percentage reduction.	
		Winter Moth.	Tortricids.		Winter Moth.	Tortricids.
Control	—	0	—	—	0	0
0·01% parathion	19th April	64	42	4th April	87*	89*
4% DNC + 0·1% DDT	15th March	75	88	8th March	90	89
4% DNC	,,	81	91	,,	85	88
0·05% DDT	19th April	89	98	4th April	85	64

*0·005% parathion. Figures in brackets do not differ significantly. ($P = 0·05$.)

The 1949 and 1950 results (Table II) both follow the same general pattern ; in each case about 80 per cent of the eggs were killed by 4 per cent DNC-petroleum spray, there being no evidence that the increased concentration of dinitro-*ortho*-cresol in 1950, from 0·075 to 0·096 per cent, caused any appreciable improvement in control, nor apparently did the addition of 0·1 per cent DDT. The failure of DDT to increase the efficacy of the spray is indeed surprising, especially as biological observations indicated that most eggs had hatched within three weeks of the time of application. When applied at the green cluster stage 0·05 per cent DDT gave control of the same order as 4 per cent DNC-petroleum, as did 0·005 per cent parathion in 1950, yet 0·01 per cent parathion in 1949 was significantly inferior. A similar effect with parathion was noted against Tortricid larvae and can possibly be explained by the time of application. In 1950 the buds varied from mouse-ear to green cluster, whilst in 1949 the green cluster stage had almost passed when spraying took place ; either the larvae were better protected within the webbed leaves or susceptibility to parathion had decreased with age.

Tortricid larvae.

The most marked effect is the high degree of control obtained by 4 per cent DNC-petroleum, and similarly with 7 per cent petroleum in 1948, against the hibernating larvae whilst still in the winter cocoons ; as with Winter Moth the addition of 0·1 per cent DDT to the DNC wash did not effect any increase in kill. Again 0·05 per cent DDT at the green cluster stage gave control which did not differ significantly from that obtained with DNC-petroleum ; the results with parathion were not consistent.

A combination of winter wash followed by DDT in the green cluster spray was investigated only in 1948 and this treatment proved superior to the others. From the results obtained during the years under review it is probable that with light infestations adequate commercial control of both

Winter Moth and Tortricid larvae can be obtained by spraying either with 4 per cent DNC-petroleum or with 0·05 per cent DDT at the green cluster stage. A combination of these measures will be advisable where heavy infestations are present.

Acknowledgements.

The authors are greatly indebted to Dr. S. C. Pearce for statistical analysis of the results, to members of the Kent W.A.E.C. who made all arrangements and carried out the spraying for the 1948 trial, and to Miss Margery Bennett who helped each year with spraying and recording.

Summary.

In spraying trials during 1949 and 1950 against the Winter Moth, *Operophtera brumata* (L.), and various species of Tortricids, equally effective control was obtained by using 4 per cent DNC-petroleum during the first half of March or 0·05 per cent DDT added to the green cluster lime-sulphur spray. Addition of 0·1 per cent DDT to the winter wash did not increase control. In 1950, 0·005 per cent parathion was very effective when applied at the green cluster stage, but less so in 1949 at 0·01 per cent.

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A NOTE ON THE SMALL ERMINE MOTH, *YPONOMEUTA PADELLA MALINELLA* ZELL.

By G. H. L. DICKER and J. B. BRIGGS

Introduction.

Nests containing larvae of the Small Ermine Moth were a familiar sight in many orchards before the introduction of efficient winter washes. This insect, however, vanished completely following the regular use of tar oil, and general observation has indicated that a spray containing DNC-petroleum, used subsequently as an alternative, is equally effective.

Since 1949 field trials have been in progress to evaluate the relative efficiency, against certain apple insects, of winter washes and various insecticides applied with the pre-blossom fungicides, during which it was observed that the omission of a winter wash resulted in the reappearance of the Small Ermine Moth. In view of the present trend towards a reduction in the winter spraying programme it is considered advisable to place these results on record, although it should be stressed that observations have so far been confined to pre-blossom sprays ; there is as yet no evidence to show whether this insect is controlled by the routine applications of insecticides at the petal fall stage.

Biology.

According to Thorpe (1929, 1931) and Beirne (1943) *Yponomeuta padella* (L.) is represented by at least four races, feeding on hawthorn, blackthorn, plum and apple, the latter being *malinella* Zell. Adults, which emerge from early July until well into August, lay eggs in batches on the shoots (Fig. 1), the average number in a batch being about 50. Immediately after oviposition the batch is covered with a glutinous substance which forms a hard protective covering, at first yellow in colour, then changing to reddish-brown and finally becoming greyish-purple, when it resembles very closely the colour of the bark.

Beirne (1943) states that hatching normally takes place about three weeks after oviposition, though a few eggs may not hatch until the early spring. The small yellow larvae remain under the egg covering until early May, when they emerge to feed on the foliage. At first the larvae live gregariously in leaf mines, later a single leaf is webbed to the shoot over the egg cluster, or two or three leaves are spun together with silken threads to form a nest within which the larvae live and feed. When the leaves have been consumed another web is made farther along the branch, first by webbing together two leaves between which the larvae congregate and then by adding others within reach (Fig. 2). A single colony occupies three or four nests in succession before the larvae reach maturity. Pupation takes place in the nest during late June or early July, the white pupal cocoons being all neatly arranged in a bundle with their axes parallel and often attached to a leaf.

TABLE I.

PERCENTAGE OF RECORDED TREES INFESTED WITH *Yponomeuta padella malinella*.

Treatment.	1949.	1950.	1951.	1951a.
Control	40	80	67	42
4% DNC in early March	0	20	0	0
4% DNC + 0·1% DDT in early March	0	0	—	—
4% DNC in early March } 0·05% DDT at green cluster }	7	—	—	—
0·05% DDT at green cluster	—	53	67	20†
0·01% parathion at green cluster	27	53*	7	20
0·1 % BHC at green cluster	—	—	67	27

* 0·005% parathion. † 0·1% DDT.

Spraying trials.

The results in Table I under the column headings 1949, 1950 and 1951 were obtained from a plot of Lane's Prince Albert, worked on seedling rootstocks, each treatment being replicated three times with five recorded trees in each plot ; the 1951a trial was on Lane's Prince Albert on Malling stocks, there being five replicates each with three recorded trees.

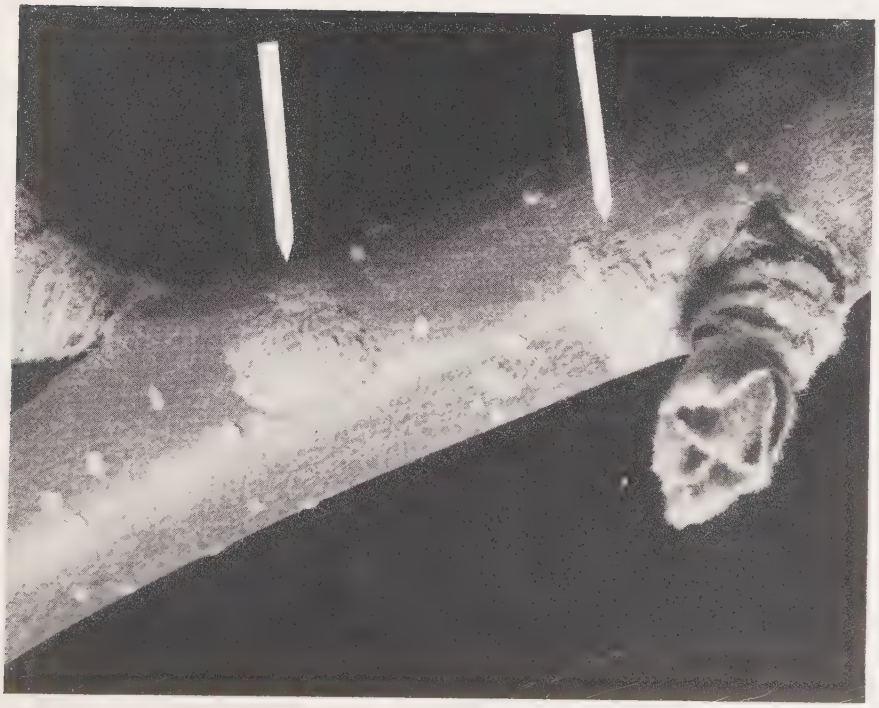

Fig. 1.
Egg batches of the Small Ermine Moth (× 5).

Fig. 2.
Leaves webbed by larvæ of the Small Ermine Moth to form nest.

Commercial formulations of all sprays were used. In 1949 the concentrate of DNC-petroleum contained 1·8 per cent dinitro-*ortho*-cresol and approximately 70 per cent mineral oil, in 1950 and 1951 the amount of dinitro-*ortho*-cresol was increased to 2·4 per cent. The DDT consisted of a wettable powder containing 20 per cent DDT on china clay, except in 1951 when a 20 per cent emulsion made with solvent naphtha, a degenerated glue and soap was used. The parathion was formulated as a 20 per cent dispersible liquid and the BHC as a 50 per cent wettable powder, the crude BHC containing approximately 13 per cent gamma isomer.

All trees received 2½ per cent lime-sulphur, to which the insecticides were added, at the green cluster stage, followed by 2 per cent lime-sulphur at the pink bud stage. No post-blossom sprays were applied.

The infestation was assessed by inspecting all trees, those containing larval nests, irrespective of the number present, being classified as infested ; not more than five larval colonies were noted on a single tree.

Discussion of results.

From Table I it will be seen that, with two exceptions, all treatments containing DNC-petroleum gave complete control ; the failures can, in all probability, be attributed to incomplete cover rather than inefficiency of the spray material. There are indications of slight reductions in infestation following applications at the green cluster stage of parathion, DDT and possibly also BHC, but the results do not suggest that any of these sprays as used would prove of value against this insect. There is thus considerable evidence to show that control of the Small Ermine Moth is unlikely to be obtained with the normal pre-blossom spray programme if winter washing is omitted. The present investigation has not been continued beyond the blossom period to investigate the effect of post-blossom sprays ; it may be that BHC or parathion used at petal fall to control Apple Sawfly, *Hoplocampa testudinea* (Klug), may be effective, but until such an assumption is proved, careful watch should be kept for the reappearance of this pest in orchards where no winter washes are applied.

Summary.

Following the omission of winter washing it has been observed that colonies of the Small Ermine Moth, *Yponomeuta padella malinella* Zell., became established even where 0·1 per cent DDT, 0·1 per cent BHC or 0·01 per cent parathion had been applied in the green cluster lime-sulphur spray. A warning is given that the present trend towards a reduction in the winter wash programme may cause the reappearance of this pest.

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SUPPLEMENTARY MEASURES FOR THE CONTROL OF CODLING MOTH, *CYDIA POMONELLA* (L.)

By JOAN R. GROVES

Introduction.

Nearly every fruitgrower in this country who is concerned about attacks of Codling Moth, *Cydia pomonella* (L.), knows that the infestation is invariably more severe around the packing shed or box stacks. But the actual potentialities of these sites as sources of infestation and the consequent loss of crop in the immediate neighbourhood have not previously been demonstrated, nor have any remedies been suggested to reduce these losses before the present investigations commenced. Since 1949 work on a detailed study of this pest has shown that, in addition to the normal population of larvae which hibernate on the trees, there are other overwintering sites, probably of still greater importance, which should be considered as the focal points of Codling Moth infestations and merit special attention when control measures are being planned.

Orchard boxes and packing sheds.

When the Codling larva is fully fed it leaves the fruit and spins a cocoon in any dry and protected spot. The crevices and corners of fruit boxes, especially in the case of early apples, may thus become infested between the picking and grading of the fruit or during despatch to the markets. Thus at the end of the season returnable boxes will contain cocoons spun by larvae originating from the many consignments of apples they have contained during the season. Further, salesmen's boxes may well contain on receipt cocoons from fruit grown in orchards where less effective measures have been taken against Codling than by the grower concerned. There was a time when growers had their own boxes into which they picked their fruit and non-returnables were often used, which meant that there were fewer salesmen's empties on the farm.

The following account provides evidence of the number of cocoons that may occur in such boxes, and of the greater intensity of Codling infestation adjacent to those places where numbers of boxes are stacked at the time of emergence of the moths in June and July, such as packing sheds, box stores and headlands. These provide ideal situations for over-wintering of Codling and evidence is given that treatment of the structure of sheds and box stacks is worth-while.

In August, 1950, some badly infested Worcester Pearmain apples were picked into boxes and left for three days before being carted away. When the boxes were emptied there were between two and six larvae spun up in the corners and joints of each box. Newly spun cocoons were also found in boxes of Cox's Orange Pippin apples when examined two days after picking in early October, 1951. A sample of boxes was examined—it must be stressed, however, that they were not taken to pieces, but the corners and all cracks were scrutinised—and of 54 boxes five had larvae in them, and over half contained empty cocoons, showing that they had harboured larvae in a past season. The boxes were taken a few from each of 10 stacks at a co-operative packhouse, and may be regarded as an average sample. Larvae have often been found on other occasions though no further counts have been made.

In 1950 treacle and molasses bait traps were used for recording flight periods of the moths, the traps being hung in an orchard adjacent to the packing shed and box store. During the latter part of July an average of one moth was trapped each night, except after the orchard boxes had been carted from the stacks to the plantations, and on these nights eight to ten moths were caught. These must have emerged from the boxes in the stacks and instead of finding their way slowly to the outside of the stack and the orchard were disturbed as the boxes were moved. It is thought very likely that many of them would normally have perished before they were able to leave the stack. This observation would seem to indicate that it is best not to distribute boxes from the stacks until they are actually required.

Again, in 1951, Cox's Orange trees in an orchard were found to have far more dropped fruit at the end by the packing shed. Investigation showed this to be due to Codling Moth ; and records show that the distribution of dropped fruit was the same the previous year. But not only were the trees nearest the packing shed the most badly infested, but the attack was also heavier on the outside trees on those sides of the plot where empties had been left and where the picked fruit had been stacked ready for collection (Fig. 1). The trees on which these observations were made form part of a manurial trial described by Hoblyn (1941).

The number of moths which emerge in a packing shed each summer gives some indication of how important it is to treat them. A daily record was made of the number of moths at the windows of a packing shed and the results are given in Table I. This number was only a percentage of the total number that emerged since the doors and windows were open. The emergence period in each season is approximately $7\frac{1}{2}$ weeks and the total number would form the nucleus of an infestation.

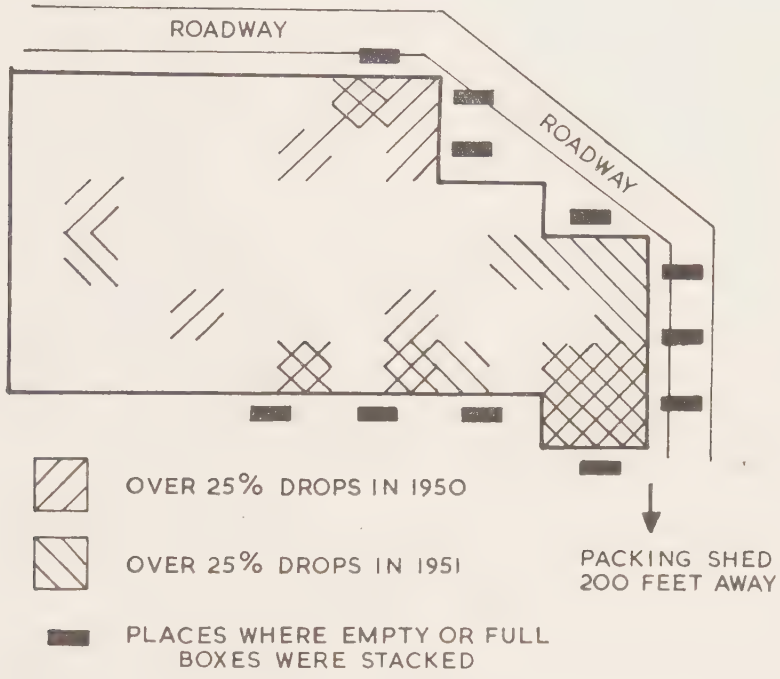

Fig. 1.
Plan of an apple plot showing the distribution of Codling Moth attack in relation to focal points of infection.

Table I.

Numbers of Codling Moths collected at the windows of a packing shed during the summers of 1949-51.

Year.	Total number of moths collected.	First moth collected.	Last moth collected.
1949	No record	25th May	24th July
1950	168	31st May	8th August
1951	124	9th June	5th August

(Note—The windows and doors were open and the shed was used as usual.)

The percentage of clean fruit picked from each tree on a plot next to the packing shed was recorded. This plot consists of four rows, each of 24 trees ; there are four varieties, and the plot is so arranged that it consists of six blocks each of which is a Latin square. The packing shed and box store are at one corner, close to blocks I and II. In 1950 the trees near the packing shed and box store had an average of only 5·4 per cent clean fruit per tree, while those further up the plot, from the tenth tree onwards, had a significantly cleaner crop, of the order of 25 per cent (Table II). In 1951 there was a still greater difference between the blocks, those near the packing shed having less clean fruit than those in the centre, which in turn had less than those at the far end of the plot.

The term " clean fruit " excludes any fruits attacked by Brown Rot (*Sclerotinia fructigena*). As Moore (1950) has demonstrated, Codling Moth is one of the chief wound agents for the Brown Rot

TABLE II.

AVERAGE PERCENTAGE OF CLEAN FRUIT PICKED FROM TREES ON AN APPLE PLOT ADJACENT TO A PACKING SHED.

Year.	Block.					
	I	II	III	IV	V	VI
1950	5·4	No record	24·7	23·3	28·6	26·4
1951	17·5		20·3	36·8	56·7	60·7

The brackets indicate differences which are not significant at the level P=0·001. They would be the same if P were to equal 0·05.

fungus. Often it is not the actual point of entry where infection takes place, but in later cracks caused by the distortion of the growing fruit. This infection of Brown Rot is demonstrated by the fact that in each season the variety picked earliest, Worcester Pearmain, had a significantly (P=0·001) higher percentage of clean fruit (37·5 and 65·1) than the other varieties, Cox's Orange Pippin having only 25·7 per cent and 26·8 per cent. This is not a true varietal susceptibility either to Codling Moth or to Brown Rot attacks. In the last week of August, when the Worcester Pearmain were picked, there was much more clean fruit on the Cox's Orange Pippin trees than when they were picked a month later ; this difference was due to Brown Rot having spread during that time although fresh entries by Codling Moth larvae did not occur. Brown Rot was directly due to Codling Moth attack and did not occur to the same extent where the trees were not so severely infested ; it could have been prevented had the pest been controlled in the early part of the season.

Rubbish dump.

There is no evidence to show that rubbish dumps and apple tips are a source of infection. There can be little danger from fruit that is well rotted in a pit.

Control measures.

The generally recommended control for Codling Moth is two applications of lead arsenate powder (2 lb. to 100 gallons of water), one the first or second week of June and another at the end of June or early July. This treatment is adequate to control the pest unless the infestation is very high, in which case supplementary measures are needed. Over 15 years ago such measures were advocated in the United States (Newcomer, 1934) and should be used more commonly in this country.

The first consideration should always be the location of the focal points which serve as centres of infection, and these should then be treated individually. It is essential that even a slight attack on a few trees should be noted and dealt with before it extends to a larger area.

Treatment of packing shed and box stacks.

The inside of the packing shed and stacks of empties, wherever situated, should be sprayed with DDT (5 lb. 20 per cent wettable powder, or the equivalent, per 100 gallons of water) during the last week in May. As much of the packing shed and its contents as possible should be sprayed, special attention being paid to the windows. Only the outside of the stacks of boxes need be sprayed, but it is essential that the top as well as the sides should be thoroughly covered. It is easiest if the boxes are built up in long, low stacks so that the sprayers can climb high enough up one side to cover the top with spray. There is no need to spray boxes that were not used the previous season.

After the inside of the packing shed has been sprayed it should be kept shut as far as possible. The critical time is from the third week in May until the end of July. Moths will often become ensnared in spiders' webs, so it is better to clear these in late summer rather than earlier in the year. It is not suggested that spiders should be encouraged, merely that they should be used to the best advantage.

The best use of lead arsenate sprays.

The spraying of the packing shed and box stacks with DDT should be regarded as supplementary control measures only, and thus it is advisable to apply an extra lead arsenate spray to the trees adjacent to these situations, unless they are an early variety which will be harvested too early in the season to allow six weeks to elapse between the last spray application and harvesting.

In any case the first trees sprayed should be those which suffered most from Codling attack the previous season. Also, when a stack of boxes is moved, lead arsenate should be applied to trees nearby, say the first three or four rows, even if this means a special application on a few trees only.

Tree banding and bark scraping.

If, despite all efforts, some trees suffer severe attack, the infestation the following season can be reduced by using corrugated paper or sack bands. It has been shown in the United States that 60 per cent of the larvae can be trapped in this way (Gould and Geissler, 1941). The bands should be placed in position in mid-July and should not be removed until after the fruit is picked. They are more effective when applied to trees with smooth bark, and it is advisable to scrape away the rough bark from beneath the bands when they are removed and clear any cracks or crevices, which often have many larvae in them. It is recommended that large holes, such as those made by the Wood Leopard Moth, *Zeuzera pyrina* (L.), should be filled with concrete to prevent the larvae hibernating there (Woodside, 1942). Eleven larvae were found in one such hole in a Laxton's Superb apple tree in an Essex orchard. The bark from older trees can be scraped and the pieces burnt to reduce the number of overwintering larvae, but this is more costly and not so satisfactory as banding.

Disposal of infested fruit.

Codling attacked fruit should always be disposed of as quickly as possible. For the general good it should not be put into market boxes ; in the packing shed metal bins or similar receptacles should be used for this and other discarded fruit and emptied at frequent intervals. More often than not it is this fruit that is left to the last.

Boxes or other receptacles containing infested fruit, especially that of early varieties, should not be left standing on the headlands or amongst the trees, as the larvae will crawl back to the adjacent trees. As far as possible different places should be used each year as this will help to prevent a build up of Codling at certain points.

Discussion.

From what has been said it is clear that what has hitherto been the generally accepted method of Codling control by one or two lead arsenate sprays may not be sufficient.

Apart from the normal method of reinfestation of trees by the Codling larvae leaving the fruit while still on the tree or on the ground and hibernating on the trunk or other suitable place, all the evidence goes to show that serious local infestation can be caused by larvae hibernating in boxes used for the picking and marketing of the fruit, and in the packing shed itself, and that unless suitable steps are taken a serious build-up can take place.

It is estimated that if only 3 per cent of the boxes in a stack have larvae in them, they will produce sufficient moths from even a small stack to cause a considerable infestation on nearby trees. It has to be remembered that each moth is capable of laying some 20 eggs.

In the packing shed the moths will often begin to emerge earlier than in the orchard, though in the United States the reverse is stated to be the case (Steiner, 1943). Thus a partial second generation is more likely to occur near the packing shed than in the rest of the orchard and at a time when it is very difficult to apply control measures on any but a late variety.

While it is not envisaged that the supplementary control measures recommended here will in themselves eliminate Codling Moth, if a better knowledge of the causes of focal points of infection is obtained, and the infestations in these situations attacked, the normal lead arsenate sprays will be far more effective.

Acknowledgements.

The writer thanks Mr. D. W. P. Greenham for the figures used in Fig. 1, and members of the Statistics Section for analysing the figures for Table II, and many others for useful discussions on the economic points considered.

Summary.

The hibernation of Codling Moth larvae in the packing shed and apple boxes is considered and examples given of the possible extent of such infestations. Attention is drawn to the danger of these forming points of infection, from which the infestation can spread to other parts of the orchard. To deal with these special measures are recommended in addition to the normal lead arsenate sprays, viz. the spraying of the packing shed and box stacks with DDT, additional lead arsenate sprays at probable points of infestation, the possible banding and scraping of trees and the prompt disposal of infested fruit.

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LIST OF INSECTS OCCURRING ON THE HOP

By J. PAINE

The following list of the insects, etc., found on hops in Kent and Sussex during 1950 and 1951 was compiled from collections made in the course of investigations into the method of spread of hop virus diseases. The frequency of their occurrence is recorded by letters placed after the names of the insects, thus : A . . . abundant and probably to be found on every hop each year, B . . . common, C . . . uncommon or local. No records of Lepidoptera were kept, although the common caterpillars such as ' Hop Dog ', and ' Hop Cat ' (or ' Yard Measure ') were frequently seen.

Insects, etc., which feed on hops.

Agriotes lineatus (L.)	B	*Lygus pabulinus* (L.)	B
Agriotes obscurus (L.)	B	*Lygus pratensis* (L.) (probably pubescens Reut.)	B
Aphthona atrovirens (Foer.)	C	*Macrosiphum euphorbiae* (Thomas)	A
Aphthona euphorbiae (Schr.)	C	Mites (not yet named)	B
Aphis spp.	A	*Monochus sp.* Predatory eelworm	C
Aphrophora spumaria (L.)	C	*Myzus spp.*	B
Atomaria nitidula (Heer)	C	*Otiorrhynchus singularis* (L.)	C
Calocoris fulvomaculatus (Deg.)	C	*Phorodon humuli* (Schr.)	A
Calocoris norvegicus (Gmelin in L.)	C	*Philaenus spumarius* (Fallén)	C
Chaetocnema concinna (Mars.)	B	*Phyllotreta vittula* (Redt.)	B
Chlorita flavescens (F.)	B	*Psylliodes attenuata* (Koch)	A
Collembola spp.	A	*Sitona lineatus* (L.)	C
Corticarina sp.	A	*Sitona tibialis* (Hb.)	C
Dorylaimus sp. Eelworm	B	*Therioaphis tiliae* (L.)	C
Epipolaeus caliginosus (F.)	C	*Tetranychus urticae* (Koch)	A
Grasshopper	B	*Thrips spp.*	A
Heterodera sp. Eelworm	A	*Triechphora vulnerata* (Gm.)	C
Liocoris tripustulatus (F.)	B	*Trioza sp.*	C
Longitarsus luridus (Scop.)	B	*Typhlocyba quercus* (F.)	C
Longitarsus parvulus (Payk.)	B	*Typhlocyba rosae* (L.)	C
Longitarsus rubiginosus (Foud.)	B		
Longitarsus succineus (Foud.)	B		

Insects, etc., which frequently occur on hops.

Acupalpus meridianus(L.)	C	*Heterogaster urticae* (F.)	A
Adalia bipunctata (L.)	B	*Liocoris tripustulatus* (F.)	B
Allothrombium fuliginosum (Herm.)	B	Millipedes	B
Amara familiaris (Dufts.)	C	*Myrrha 18-guttata* (L.)	B
Anthicus antherinus (L.)	A	*Nabis apterus* (F.)	B
Anthocoris confusus (Reut.)	B	*Nabis ferus* (L.)	B
Anthocoris nemoralis (F.)	A	*Nabis lativentris* (Boh.)	C
Anthocoris nemorum (L.)	A	*Notiophilus biguttatus* (F.)	B
Anystis agilis (Banks)	C	*Orius majusculus* (Reut.)	C
Apion aestivum (Gm.)	B	*Orius minutus* (L.)	C
Apion miniatum (Gm.)	B	*Rhyzobius litura* (F.)	C
Atheta spp.	C	*Sciarinae* larvae	B
Bembidium aeneum (Gm.)	C	*Stenodema laevigatum* (L.)	C
Calvia 14-guttata (L.)	B	*Tachyporus hypnorum* (F.)	C
Chrysopa sp.	C	*Trechus 4-striatus* (Schr.)	C
Coccinella 7-punctata (L.)	B		

Occasional visitors to hops.

Adela viridella (Scop.)	C	*Hermaeophaga mercurialis* (F.)	C
Anobium sp.	C	*Heterotoma meriopterus* (Scop.)	C
Aphodius punctatosulcatus (Sturm.)	C	*Hylesinus fraxini* (Pz.)	C
Aphodius pusillus (Herbst)	C	*Laria rufimanus* (Boh.)	C
Atomaria nitidula (Heer)	C	*Lathridius nodifer* (Westw.)	C
Brachypterus glaber (St.)	C	*Meligethes aeneus* (F.)	C
Camptobrochis lutescens (Sch.)	C	*Necrobia violacea* (L.)	C
Capsus meriopterus (Scop.)	C	*Omosita colon* (L.)	C
Centipedes	C	*Phyllobius pomonae* (Ol.)	C
Chironomidae. Midges	C	*Phyllobius pyri* (L.)	C
Cicadella aurata (L.)	C	*Plagiognathus arbustorum* (F.)	C
Coeliodes erythroleucus (Gmelin in L.)	C	*Rhagonycha fulva* (Scop.)	C
Corynetes caeruleus (Deg.)	C	Snow fly	C
Demetrias atricapillus (L.)	C	*Stenotus binotatus* (F.)	C
Demetrias monostigma (Sam.)	C	*Stilbus testaceus* (Pan.)	C
Harpalus aenus (F.)	C	*Troilus luridus* (F.)	C

Acknowledgments.

The collections were made with the assistance of Messrs. P. J. Ormerod and J. F. Wilson ; the naming of the species was done by Dr. A. M. Massee and his staff, without whose assistance the list could not have been compiled.

OBSERVATIONS ON *LYGUS PABULINUS* (L.), A PEST OF RASPBERRIES IN SCOTLAND

By A. R. HILL*
A.R.C. Scottish Raspberry Investigation

The most conspicuous damage caused to raspberries by *Lygus pabulinus* (L.), the green capsid bug, is severe perforation of the leaves. This, however, seems in most cases to do little harm to the plants and does not concern the grower much as the fruits are unaffected. In addition, however, this capsid is capable of causing branching of the canes by attacking and killing the growing point of the main shoot. This has been shown by artificially infesting raspberry plants with immature and adult capsids. In one experiment four potted Norfolk Giant raspberry plants were each enclosed in individual muslin cages after having been fumigated with nicotine. Three of the plants were then each infested with five nymphs of *L. pabulinus*. No insects were placed on the fourth plant, which acted as a control. All four plants were kept in an unheated glasshouse for three weeks ; at the end of this period the three infested plants had branched while the control plant was normal. A similar experiment in which 14 adults of *L. pabulinus* were applied to each of the three experimental plants, gave similar results.

In the field such branching, when plentiful, not only renders plantations unsightly but makes more difficult the task of tying-in the canes.

Three distinct types of branching have been observed in plantations, but of these only two seem to be due to *Lygus* attack. The first occurs in early spring when the young canes are just appearing above the ground. This form of branching appears normally before *L. pabulinus* is active and is thought to be the result of frost damage or of some other mechanical injury. The second type of branching occurs at a height of about 3 feet from the ground and is usually most evident in late July and August ; this is the form which causes most concern to the growers. The third form of branching becomes evident in late September and takes the form of a crown of small branches near the tip of a tall, almost full-grown cane ; although unsightly, this does not greatly inconvenience the grower.

Note on the life-cycle in Scotland.

The following observations on the behaviour and times of appearance of the various stages of *L. pabulinus* have been made at a number of fruit farms in Scotland, over a period of three years.

Nymphs first appear on the raspberry plants during the last week of May. As all eggs do not hatch simultaneously, there is a gradual increase in the numbers of nymphs, until, by the third week in June, they are very plentiful, some having attained the fourth instar, others being only second instar forms. By the first week of July the earliest adults appear in small numbers and about 7-10 days later they are abundant. During the first half of August the population of adults decreases steadily until by the end of the third week no adults are to be found.

However, by the middle of August a second generation of nymphs hatches from eggs laid on the raspberries by the summer adults. These nymphs are present on the plants until late September and early October, by which time they are full-grown and moulting to assume adult form. The autumn generation of adults proceeds to oviposit on the raspberry canes and in the egg stage the species survives the winter.

The observations outlined above are not in full agreement with some earlier views (Petherbridge and Thorpe, 1928) that most young nymphs of the first generation leave the winter hosts (in the present instance raspberries) and migrate to herbaceous plants. This would imply that mainly first or second instar nymphs do damage to the raspberries, whereas in Scotland a large proportion of individuals pass their entire life-cycle on the woody plants. In addition their progeny remain on the fruit plants and finally oviposit there in early autumn. This account is more in keeping with Dicker's statement (1939) that there is " . . . adequate evidence to show that many of the first generation adults do not migrate ", and supports his further assertion that these adults " deposit eggs on many young canes of the original host plant."

It is clear that, in Scotland at least, the green capsid bug is capable of damaging raspberry plants throughout a prolonged period of weeks and not only in early and late summer. This explains the second and third type of branching described above, the second being caused by the attacks of the

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first generation while the third is due to attacks by members of the second generation which have remained on the canes.

Summary.

In addition to perforation of the leaves, the green capsid bug, *Lygus pabulinus* (L.), has been shown to cause branching of raspberry canes by damaging the growing points.

Observations over a period of three years have shown that in Scotland two generations occurred each year on raspberry. This would seem to indicate a different behaviour from that described by some earlier writers who considered that this species migrated to herbaceous plants in early summer.

References

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PLANT PROTECTIVE CHEMISTRY

SPRAY DAMAGE INVESTIGATIONS IN 1949-51

By A. H. M. KIRBY and MARGERY BENNETT

Trials on apple and pear.

Trials to determine the safety or otherwise of a number of chemicals and mixtures of chemicals to leaves and fruit were carried out in 1949, 1950 and 1951. Trees, approximately 15 years old, of Cox's Orange Pippin on M.XII were used in each year ; Worcester Pearmain trees on M.IX, of the same age, were used in 1949 and 1950, and a row of alternate Cox's Orange Pippin and Beauty of Bath, on M.IX, were used in 1949 only.

Post-blossom routine sprays were avoided in order to simplify the issue ; the main difficulty resulting was a high incidence of Codling Moth.

In each season, treatments were applied to single branches of the large Cox's Orange Pippin trees on M.XII ; by using four sides of each tree, four treatments could be applied per tree. For six replicates of 12 treatments, 18 trees were required ; alternate trees were left as guards. In the winter of 1950-51, alternate trees were grubbed, and all remaining trees used for treatments, but the large gaps between trees served to minimize drift. The small Cox's Orange Pippin, Beauty of Bath and Worcester Pearmain trees on M.IX were used as single-tree plots ; the first two varieties were grubbed in the winter of 1949-50. Two types of hand-sprayer were used, and two mechanical sprayers, of which the 2 h.p. machine developed about 300 lb. per square inch, and the 1·2 h.p. machine about 80 lb.

Materials tested for phytotoxicity were new fungicides and new insecticides, including acaricides and summer ovicides, and mixtures of certain of these new materials with materials already in general use. Information regarding the chemistry and performance of the fungicides (other than copper cuprosulphite) are given on page 200. Remarkable claims for mildew control on vines by copper cuprosulphite included the assertion that both copper and sulphur were very slowly liberated in toxic forms only under weather conditions favouring spread of the disease (d'Estivaux, 1948). Tests for phytotoxicity alone were made on apples, using three samples ; two were prepared at the Chemical Research Laboratory, Teddington, from copper sulphate and potassium bisulphite, and the third was a commercial sample. Of the two Teddington samples, the 1949 batch had a copper content of 43·05 per cent and the 1951 batch 46·0 per cent, compared with the theoretical requirement of 49·3 per cent for $Cu(CuSO_3)_2 \cdot 2H_2O$. The commercial sample had 48·24 per cent copper in it, corresponding most nearly of the three samples to theory.

Information regarding the insecticides used is incorporated in Table I. Mixtures were applied of lime-sulphur or the glyoxalidine fungicide, 341C, with one or other of three metallic arsenates : (*a*) lead arsenate ; (*b*) zinc fluoroarsenate, of Swedish origin, (i) 1946 consignment, (ii) 1951 consignment ; (*c*) aluminium arsenate. Laboratory tests indicated that the content of water-soluble arsenic, expressed as As_2O_5, was (*a*) 0·0004 per cent ; (*b*) 0·0002 per cent, and (*c*) 0·002 per cent. Chemical analyses indicated a much greater release of soluble arsenic when lead arsenate was mixed with dilute lime-sulphur than when zinc fluoroarsenate was so mixed ; no extra soluble arsenic was set free in the case of aluminium arsenate mixtures.

American reports that glyoxalidine fungicides were not compatible with γ-benzene hexachloride led to tests of such mixtures here, and mixtures of phenyl mercury chloride with BHC or toxaphene were also tested.

Although no pear trees were available in 1949-50 for phytotoxicity tests as such, evidence for the effect of fungicides on foliage was obtained from fungicide trials in those years and in 1951. Bordeaux, at 4 : 6 : 100, was used as standard in 1949 and 1950 ; no damage was observed in 1949, but severe scorch and leaf fall occurred in 1950.

Results of trials on apples are presented in Table I, and on pears in Table II.

Special studies.

In addition to the trials reported above, experiments have been carried out on other aspects of spray damage ; these are reported below.

HETP on gooseberries.

Damage to Careless and other varieties by HETP sprays was reported from Surrey in 1949 ; in 1950, leaf and fruit drop on White Lion was reported from Sussex. Plots of Leveller and Keepsake were sprayed on this Station with 0·0375 per cent HETP plus 0·025 per cent Agral LN on 28th May, 1950 ; leaf and fruit fall were noticed on the former on 7th June, but not on the latter variety. As these bushes had been sprayed with 2 per cent lime-sulphur at the beginning of April without causing leaf fall, HETP was applied on 24th May to other plots of these two varieties at 0·1, 0·05 and 0·025 per cent of the commercial product, plus 0·05 per cent Lissapol NXA. No leaf damage or fall or fruit fall was seen on either variety up to the time of picking.

Toxaphene on plums.

Reports were received in 1951 that toxaphene sprays had caused scorch in 6 to 20 days on Victoria at two farms ; Rivers' Early, Warwickshire Drooper and Giant Prune were also affected, but not Oullins Golden Gage or Bush. A few six-year-old Victoria trees on their own roots at this Station were sprayed, using the 1·2 h.p. machine, on 9th August in two formulations : (*a*) emulsified with 0·05 per cent Lissapol NXA ; (*b*) dissolved in 10 parts diacetone alcohol, with 0·05 per cent MB320 and 0·01 per cent Aerosol OT. No damage to leaves or crop was visible by 24th August.

Bordeaux-wetter damage on apples.

A report from the Wye, Kent, area that scorch of leaves of Newton Wonder and Bramley's Seedling had followed applications (end of June and mid-July) of lead arsenate plus a commercial wetter was followed up. Sample leaves showed damage more reminiscent of copper than of arsenic, and tests for copper on the spray-residue present were strongly positive. The grower subsequently stated that five applications of Bordeaux had been made on the Newton Wonder trees and four on the Bramley's Seedling prior to the lead arsenate sprays ; it was concluded that the damage was due to release of copper by the wetter in the lead arsenate preparation.

Acknowledgements.

The authors wish to acknowledge help from Mr. R. P. Tew with formulations and from Miss W. M. Phillips with analyses ; and also to thank Mr. J. Idris Jones, Chemical Research Laboratory, Teddington, for two preparations of copper cuprosulphite used in these trials.

Summary and conclusions.

Routine tests for phytotoxicity on new spray materials and mixtures on certain apple varieties are reported for three seasons ; results for some fungicides on several pear varieties are given for the same period.

Fungicides based on 2-alkylglyoxalidines or on N-trichlormethylthiotetrahydrophthalimide (S-trichlormethyl-N-tetrahydrophthalylsulphenamide) were very safe on apples and pears in all trials.

A remarkable difference in phytotoxicity was found between two very closely related nitrosopyrazoles on apples.

Three samples of copper cuprosulphite caused leaf fall on apples when used at 0·2 per cent copper content, but only leaf spotting at 0·15 per cent, or less. One sample, at 0·1 per cent, was safe on pears in a year when Bordeaux was also safe, but another sample caused scorch and leaf fall in a year when Bordeaux was damaging.

A 25 per cent wettable powder based on 2, 4-dinitro-6-caprylphenyl crotonate was safe on pears in one season.

Damage on apples followed the use of a commercial formulation of bis-(*p*-chlorphenyl)methyl carbinol, and also laboratory formulations of azoxybenzene and alkyl, C_{12}-C_{13}, thiocyanates.

No damage was observed on apples following applications of aldrin, dieldrin, toxaphene, 2-nitro-1,1-bis-(*p*-chlorphenyl)-propane or -butane, or both, diethyl-7(4-methylcoumarinyl) thionphosphate, ethyl-*p*-nitrophenyl phenylthionphosphonate, or *p*-chlorphenyl *p*-chlorbenzenesulphonate.

Damage was observed on apples in one year following sprays of lime-sulphur with either lead or aluminium arsenate or zinc fluoroarsenate, but not in either of the other years ; a factor or factors would appear to be involved besides the presence of soluble arsenic.

No damage was seen on apples following applications of alkylglyoxalidines plus commercial BHC wettable powder in either of two years.

Applications of phenyl mercury chloride plus either commercial BHC wettable powder or laboratory-formulated toxaphene were safe on apples in one season.

TABLE I.

SPRAY DAMAGE STUDIES, 1949-51; APPLE TRIALS.

Material	Formulation.	Variety and Rootstock	Year.	Date	Concentration of formulated material per 100 gals., and pressure	Damage.
NEW FUNGICIDES.						
2-ALKYLGLYOXALIDINES:						
2-Heptadecylglyoxalidine 33% 2-Pentadecylglyoxalidine 16% 2-Heptadecenylglyoxalidine 1% Isopropanol 50% } 341C	Free bases released by adding ⅛ lb. slaked lime per 100 gals. spray in tank.	Cox's Orange Pippin/M.IX	1949	31st May	2 qts.*(i)	None.
		Cox's Orange Pippin/M.XII Worcester Pearmain/M.IX	1950	24th May	3 qts.***(ii)	None.
		Cox's Orange Pippin/M.XII	1951	27th June	3 qts.**(ii)	None.
2-Heptadecylglyoxalidine 34% Isopropanol 66% } 341SC	Free base released by adding ⅛ lb. slaked lime per 100 gals. spray in tank.	Cox's Orange Pippin/M.IX	1949	31st May	3 qts.*(i)	None.
		Cox's Orange Pippin/M.XII Worcester Pearmain/M.IX	1950	24th May	4½ qts.***(ii)	None.
		Cox's Orange Pippin/M.XII	1951	27th June	4½ qts.**(ii)	None.
COPPER CUPROSULPHITE:						
Sample 1: 43·05% copper	Methyl cellulose used as dispersing agent.	Cox's Orange Pippin/M.XII Worcester Pearmain/M.IX	1949	16th June	3 lb.*	**Leaf spotting.**
		Cox's Orange Pippin/M.IX	1950	16th June	2 lb.***	**Leaf spotting.**
		Cox's Orange Pippin/M.XII	1951	27th June	4·7 lb.**	**Considerable leaf fall in 12 days.**
Sample 2: 48·24% copper	Methyl cellulose used as dispersing agent.	Cox's Orange Pippin/M.XII Worcester Pearmain/M.IX	1950	24th May	4 lb.***	**Considerable leaf fall in 15 days.**
		Cox's Orange Pippin/M.IX	1950	16th June	2 lb.***	**Leaf spotting.**
		Cox's Orange Pippin/M.XII	1951	27th June	4·2 lb.**	**Leaf fall in 12 days.**
Sample 3: 46·00% copper	Methyl cellulose used as dispersing agent.	Cox's Orange Pippin/M.XII	1951	27th June	4·3 lb.**	**Leaf fall in 12 days.**
N-Trichlormethylthiotetrahydrophthalimide (S-Trichlormethyl-N-tetrahydrophthalylsulphenamide, S.R. 406)	50% wettable powder.	Cox's Orange Pippin/M.XII Worcester Pearmain/M.IX	1949	16th June	2 lb.*	None.
		Cox's Orange Pippin/M.XII	1951	27th June	4 lb.**	None.
PYRAZOLES:						
1-*p*-Chlorphenyl-3,5-dimethyl-4-nitrosopyrazole (J49)	Methyl cellulose used as dispersing agent.	Cox's Orange Pippin/M.XII	1951	27th June	1 lb.**(iii)	**Slight scorch.**
		Cox's Orange Pippin/M.VII	1951	9th August	1 lb.*(iv)	**Slight scorch.**
		Worcester Pearmain/M.VII	1951	9th August	1 lb.*(iv)	None.
1-Phenyl-3,5-dimethyl-4-nitrosopyrazole (J55)	Methyl cellulose used as dispersing agent.	Cox's Orange Pippin/M.XII	1951	27th June	1 lb.**	**Marginal scorch.**
		Cox's Orange Pippin/M.VII	1951	9th August	1 lb.*(iv)	**Considerable leaf fall after scorch.**
		Worcester Pearmain/M.VII	1951	9th August	1 lb.*(iv)	**Dull red coloration on some leaves.**
NEW INSECTICIDES.						
Bis-(*p*-chlorphenyl)methyl carbinol (DMC)	Commercial emulsion [illegible]	Cox's Orange Pippin/M.XII	1949	15th June	2 lb.*(v)	**Scorch, leaf fall.**
		Worcester Pearmain/M.IX	1949	18th June	2 lb.*(v)	None.
Alkyl thiocyanates (based on synthetic C_{12}-C_{13} alcohols)	Lissapol N as dispersing agent.	Cox's Orange Pippin/M.XII	1949	18th May	4 lb.*	**Slight scorch.**
		Worcester Pearmain/M.IX	1949	18th May	4 lb.*	None.
		Cox's Orange Pippin/M.XII Worcester Pearmain/M.IX	1949	18th May	2 lb.*	None.
Azoxybenzene	Diacetone alcohol as solvent; Lissapol N as dispersing agent.	Cox's Orange Pippin/M.XII Worcester Pearmain/M.IX Beauty of Bath/M.IX	1949	18th May	1 lb.*	**Scorch.**
			1949	18th May	1 lb.*	None.
CHLORINATED ETHER-ARGOS:						
Aldrin (95% pure)	Diacetone alcohol as solvent; MB320 and Aerosol OT as dispersing and wetting agents.	Cox's Orange Pippin/M.IX Worcester Pearmain/M.IX	1950	6th June	1 lb.*(vi)	None.
		Cox's Orange Pippin/M.XII	1951	27th June	1 lb.**(vi)	None.
Dieldrin (85% pure)	Diacetone alcohol as solvent; MB320 and Aerosol OT as dispersing and wetting agents.	Cox's Orange Pippin/M.IX Worcester Pearmain/M.IX	1950	6th June	1 lb.*(vi)	None.
		Cox's Orange Pippin/M.XII	1951	27th June	1 lb.**(vi)	None.
Toxaphene (Chlorinated camphene)	Diacetone alcohol as solvent; Lissapol N as dispersing agent.	Cox's Orange Pippin/M.XII Worcester Pearmain/M.IX	1949	16th June	1 lb.*	None.
NITRO-PARAFFINS:						
2-Nitro-1,1-bis-(*p*-chlorphenyl)propane (sample labelled 100%)		Cox's Orange Pippin/M.XII	1951	27th June	1 lb.**	None.
2-Nitro-1,1-bis-(*p*-chlorphenyl)butane (sample labelled 100%)		Cox's Orange Pippin/M.XII	1951	27th June	1 lb.**	None.
2-Nitro-1,1-bis-(*p*-chlorphenyl)propane, plus 2-nitro-1,1-bis-(*p*-chlorphenyl)butane, as 1:2 (Dilan)		Cox's Orange Pippin/M.XII	1951	27th June	1 lb.**	None.
ORGANOPHOSPHORUS ESTERS:						
Diethyl-7(4-methylcoumarinyl) thionphosphate (E838)	Purified from commercial material by passage in benzene through alumina and crystallization. Formulated as for toxaphene.	Cox's Orange Pippin/M.XII	1951	27th June	½ lb.**(vii)	None.
Ethyl-*p*-nitrophenyl phenylthionphosphonate (EPN 300)	Diacetone alcohol as solvent; Lissapol NX as dispersing agent.	Cox's Orange Pippin/M.XII	1951	27th June	½ lb.**(vii)	None.
p-Chlorphenyl *p*-chlorbenzenesulphonate (K6451)	Acetone as solvent; MB320 and Aerosol OT as dispersing and wetting agents.	Cox's Orange Pippin/M.XII	1951	27th June	2 lb.**(i)	None.
MIXED SPRAYS.						
ARSENICALS:						
Lead arsenate + lime-sulphur		Cox's Orange Pippin/M.XII	1949	17th June	2 lb.+1 gal.***	**Leaf scorch.**
		Worcester Pearmain/M.IX	1949	17th June	2 lb.+1 gal.***	None.
		Cox's Orange Pippin/M.XII Worcester Pearmain/M.IX	1950	24th May	2 lb.+1 gal.***	None.
		Cox's Orange Pippin/M.XII Worcester Pearmain/M.IX	1950	23rd August	2 lb.+1 gal.***(viii)	None.
		Cox's Orange Pippin/M.XII	1951	27th June	2 lb.+½ gal.**	None.
Lead arsenate+341C		Cox's Orange Pippin/M.XII Worcester Pearmain/M.IX	1949	17th June	2 lb.+1 qt.***	None.
		Cox's Orange Pippin/M.XII Worcester Pearmain/M.IX	1950	24th May	2 lb.+1 qt.***	None.
		Cox's Orange Pippin/M.XII Worcester Pearmain/M.IX	1950	23rd August	2 lb.+1 qt.***(viii)	None.
		Cox's Orange Pippin/M.XII	1951	27th June	2 lb.+1 qt.**	None.
Zinc fluoroarsenate+lime-sulphur	1946 sample of arsenate.	Cox's Orange Pippin/M.XII	1949	17th June	2 lb.+1 gal.***	**Leaf scorch.**
		Worcester Pearmain/M.IX	1949	17th June	2 lb.+1 gal.***	None.
		Cox's Orange Pippin/M.XII Worcester Pearmain/M.IX	1950	24th May	2 lb.+1 gal.***	None.
		Cox's Orange Pippin/M.XII Worcester Pearmain/M.IX	1950	23rd August	2 lb.+1 gal.***(viii)	None.
		Cox's Orange Pippin/M.XII	1951	27th June	2 lb.+½ gal.**	None.
	1951 sample of arsenate.	Cox's Orange Pippin/M.XII	1951	5th July	2 lb.+½ gal.**	None.
Aluminium arsenate+lime-sulphur	Arsenate ground to pass 100-mesh sieve.	Cox's Orange Pippin/M.XII	1949	17th June	2 lb.+1 gal.***	**Leaf scorch.**
		Worcester Pearmain/M.IX	1949	17th June	2 lb.+1 gal.***	None.
		Cox's Orange Pippin/M.XII Worcester Pearmain/M.IX	1950	24th May	2 lb.+1 gal.***	None.
		Cox's Orange Pippin/M.XII Worcester Pearmain/M.IX	1950	23rd August	2 lb.+1 gal.***(viii)	None.
		Cox's Orange Pippin/M.XII	1951	27th June	2 lb.+½ gal.**	None.
BHC+341:						
BHC+341SC	BHC 50% wettable powder containing 0·5% γ-isomer.	Cox's Orange Pippin/M.XII Worcester Pearmain/M.IX	1950	24th May	2 lb.+3 pts.***	None.
BHC+341C	BHC 50% wettable powder containing 0·5% γ-isomer.	Cox's Orange Pippin/M.XII	1951	27th June	2 lb.+1 qt.**	None.
BHC+Phenyl mercuric chloride	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] 2 lb.**	None.
Toxaphene+Phenyl mercury chloride	PMC 2·5% wettable powder.	Cox's Orange Pippin/M.XII	1951	27th June	1 lb.+2 lb.**	None.

* Hand sprayer. ** 1·2 h.p. pump giving 80-100 lb. per square inch. *** 2 h.p. pump giving 300-400 lb. per square inch. (i) Twice the recommended concentration. (ii) Thrice the recommended concentration. (iii) Material tended to separate in sieves of machine. (iv) Material prepared in fine state of division. (v) Four times recommended concentration. (vi) Twice concentration likely to be required for control of pests. (vii) Five times recommended concentration. (viii) Mixture allowed to stand 24 hours in open buckets and re-suspended before spraying.

TABLE II.

SPRAY DAMAGE STUDIES, 1949-51; PEAR TRIALS.

Material.	Formulation.	Variety and rootstock.	Year.	Date.	Concentration of formulated material per 100 gals., and pressure.	Damage.
Copper cuprosulphite (sample 1)	Methyl cellulose as dispersing agent.	Williams' Bon Chrétien/Reine de Poires/various.	1949	14th June	2-4 lb.***	None.
		Williams' Bon Chrétien/Hardy/Quince C. Doyenné du Comice/Quince C. Dr. Jules Guyot/Quince C.	1950	3rd May	2 lb.*	**Scorch and leaf fall.**
2-ALKYLGLYOXALIDINES (341C): 2-Heptadecylglyoxalidine 33% 2-Pentadecylglyoxalidine 16% 2-Heptadecenylglyoxalidine 1% Isopropanol 50%	Free bases released by adding ½ lb. slaked lime per 100 gals. spray in tank.	Williams' Bon Chrétien/Reine de Poires/various.	1949	14th June	1 qt.***	None.
		Williams' Bon Chrétien/Hardy/Quince C. Doyenné du Comice, Quince C. Dr. Jules Guyot/Quince C.	1950	3rd May	1 qt.*	None.
		Williams' Bon Chrétien/Hardy/Quince C. Doyenné du Comice/Quince C. Dr. Jules Guyot/Quince C.	1951	21st May	1 qt.*	None.
N-Trichlormethylthiotetrahydrophthalimide (S-trichlormethyl-N-tetrahydrophthalylsulphenamide, S.R.406)	50% wettable powder.	Williams' Bon Chrétien/Hardy/Quince C. Doyenné du Comice/Quince C. Dr. Jules Guyot/Quince C.	1950	3rd May	2 lb.*	None.
		Williams' Bon Chrétien/Hardy/Quince C. Doyenné du Comice/Quince C. Dr. Jules Guyot/Quince C.	1951	21st May	2 lb.*	None.
2,4-Dinitro-6-caprylphenyl crotonate	25% wettable powder.	Williams' Bon Chrétien/Reine de Poires/various.	1949	14th June	1 lb.***	None.

* Hand sprayer. ** 1·2 h.p. pump giving 80-100 lb. per square inch. *** 2 h.p. pump giving 300-400 lb. per square inch.

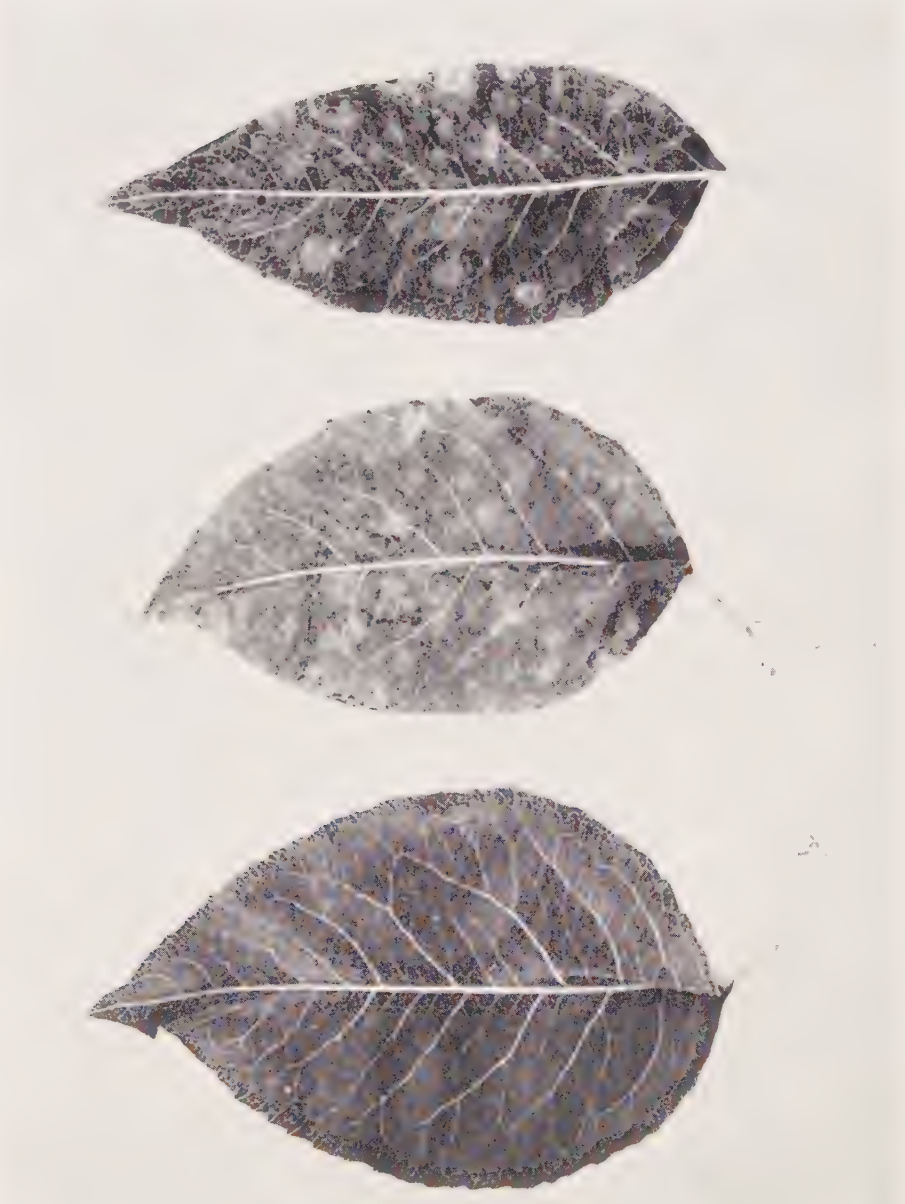
No damage was observed on two varieties of gooseberry sprayed with half, once, or twice the recommended strength of HETP in one season.

Plums sprayed with toxaphene in one or other of two laboratory formulations showed no damage in one season.

Damage to leaves and fruit of two culinary apple varieties following sprays of lead arsenate plus a wetter was almost certainly due to the action of the wetter on Bordeaux deposits already present.

Reference

d'Estivaux, M. L. Baillot (1948). *C.R. Acad. Agric. Fr.*, **34**, 37-40.



(a) (b) (c)

Fig. 1.

(a) Normal leaf: (b) and (c) leaves, sprayed with 0·01 per cent phenyl mercury chloride, showing pale areas on upper surface.

AN EFFECT OF PHENYL MERCURY CHLORIDE ON PEAR LEAVES

By A. H. M. KIRBY and MARGERY BENNETT

Introduction.

Phenyl mercury chloride precipitated on lead arsenate has been in use for some years on apples (Shaw and Moore, 1945) ; the first routine use of this combined fungicide-insecticide at this Station on pears seems to have been in 1950, when a green cluster application of lime-sulphur was followed by two applications of mercurated lead arsenate at 2 lb. per 100 gallons at petal-fall and fruitlet stages respectively. No spray damage was reported and it seems unlikely that it occurred.

In 1951, mercurated lead arsenate was used on pears for the green cluster stage as well as the two post-blossom applications, all at 2 lbs. per 100 gallons. At the end of June attention was drawn to a plot of pears, six each of the following eight varieties on Quince A and six each on Quince C : Beurré Superfin, Laxton's Superb, Emile d'Heyst, Durondeau, Doyenné du Comice, Comtesse de Paris, Fondant d'Automne and Conference. Leaves of all these varieties showed pale spots on the upper surface and white or brown spots (deposit) on the under surface immediately below. As the only post-blossom spray had been mercurated lead arsenate, the damage was attributed to it.

It was subsequently reported that essentially similar damage had been found on Doyenné du Comice and Glou Morceau (and to a lesser degree on Doyenné d'Eté) on Quince A or C in Bradbourne Gardens. Here it was first seen on 29th May, following the last spray on 23rd May.

As a block of young Conference trees on Quince A, which had received no sprays, was available, an experiment was designed to test the effects of a single application of phenyl mercury chloride, with or without lead arsenate.

Experimental Details.

Single tree plots of Conference on Quince A were used, with screening, and five treatments were randomized in five blocks. Applications were made on 5th July in fine weather at about 300 lbs. per square inch pressure, of the following materials :

1.	Phenyl mercury chloride (on china clay)	0·005 per cent PMC
2.	,, ,, ,, ,,	0·01 per cent PMC
3.	Mercurated lead arsenate	0·005 per cent PMC
4.	,, ,, ,,	0·01 per cent PMC
5.	Unsprayed.	

Treatment 3 corresponded to the farm spray used earlier in the year elsewhere.

No damage was visible on 10th July, although white or brown spray-deposit was present, except on unsprayed foliage. By 24th July, however, young leaves of sprayed trees exhibited a mottled appearance similar to that seen earlier on the plot mentioned above ; sprayed leaves are contrasted with an unsprayed leaf in Fig. 1. As to be expected, the damage was greater on leaves receiving treatments 2 and 4. Again the pale areas on the upper surface corresponded to spray-deposit on the lower.

Observations on 25th September, and again on 1st November, showed that the brown deposits on the under side of leaves had persisted, and that the corresponding pale areas on the upper surface were also clearly visible, but had not increased in size. Treatments 2, 3 and 4 seemed to be more affected than treatment 1.

Chlorophyll estimation.

As the damage appeared to be related to chlorophyll content, estimations of this pigment were undertaken at the end of July. Eight leaves were collected from each replicate of each treatment, giving 25 batches of leaves which were separately disintegrated in a high-speed blender under 100 ml. ethanol and then allowed to stand overnight in the dark. The alcoholic solutions were freed from suspended material by centrifuging and the density of colour measured in a "Spekker" absorptiometer, using filter No. 608 and an ethanol blank. The readings were converted by means of a standard curve to " units " of chlorophyll per gram (fresh weight) of leaves ; the results were as follows :

Treatment :	5	1	3	4	2
Chlorophyll : in units/gram	1076	928	787	752	701

Sig. diff. ($P = 0{\cdot}05$)$=362$. Figures bracketed together do not differ significantly.

Discussion.

A single application of 0·01 per cent phenyl mercury chloride to leaves of Conference pear trees on Quince A reduced the chlorophyll content by over 30 per cent. An application at half this strength also reduced the chlorophyll in the leaves, but the degree was clearly less, and the same is true of applications of either strength in the presence of lead arsenate.

The nature of the damage seems to be the same as that reported for Cox's Orange Pippin on M.IX after spraying twice pre-blossom and twice post-blossom with 0·01 per cent phenyl mercury chloride in sulphite lye suspension in 1942 (Shaw and Moore, 1945), but in the case of pears there was no leaf-drop.

That this form of damage was evinced by 10 varieties of pear on three different sites with trees of different ages and methods of culture, and on two rootstocks, suggests that the risk to pears is a general one ; nevertheless, the absence of damage in 1950 on those trees which received mercurated lead arsenate that year may indicate that it will only occur in certain seasons.

Acknowledgements.

The authors are grateful to Mr. M. Allen and Mr. F. W. M. Llewelyn for carrying out the chlorophyll estimations.

Summary.

Damage to leaves of 10 varieties of pears following post-blossom sprays of mercurated lead arsenate was reported in 1951, but not in 1950.

In 1951, similar damage followed one application of phenyl mercury chloride on china clay or on lead arsenate to leaves of Conference. In the case of PMC on clay at 0·01 per cent, the chlorophyll was reduced by over 30 per cent. Leaf fall did not occur.

Reference

Shaw, H. and Moore, M. H. (1945). "Mercurated lead arsenate"—What is it ? What does it do ? *Rep. E. Malling Res. Sta. for 1944*, 128-30.

HOPS

SEVEN CLONAL SELECTIONS OF GOLDING HOPS

By F. H. BEARD

Introduction.

Many brewers, particularly those producing high quality pale ales, consider that English Goldings are the most suitable hops for their purpose. Though their preservative value is usually rather higher than that of the Fuggle, the Goldings are appreciated for their delicacy of aroma. In spite of the valuation placed on Golding growths,* the acreage planted is relatively small and has tended in recent years to decrease rather than to increase. This is due to a number of factors ; Goldings are more particular in their soil requirements, are more prone to Downy Mildew and are more difficult to pick than the Fuggle. They are also liable to suffer from a lethal virus disease, known as ' Mosaic ', which is particularly prevalent in those areas, such as the Teme Valley in Worcestershire, where Goldings are grown near the Fuggle, a ' carrier ' of the disease. Though Goldings occupy less than a quarter of the hop acreage there are at least seven ' varieties ' in cultivation and there has been little reliable information as to which of these are the best from either the grower's or brewer's point of view. It would simplify the provision of sound material for the establishment of new gardens if there were available three selected Goldings of early, mid and late season respectively.

When the hop programme at East Malling was extended in 1927 provision was made for work on the classification and improvement of the Golding hops on the lines that had proved so successful in the case of soft fruits.

The original Golding hop is said to have been raised at the end of the 18th century from a ' Canterbury Hop ', Canterbury Whitebine (Percival, 1901, p. 88), by a Mr. Golding of Malling. It has been suggested (Beard, 1943) that the several Golding ' varieties ' have all risen as selections, probably of mutations or bud-sports, from a single parent type. This suggestion is supported by what is known of their history.

Origin of clones.

Professor E. S. Salmon and several hop growers have since kindly provided the writer with fuller particulars of the original stocks, obtained in 1919-20, from which the East Malling clones were eventually raised. These particulars, together with anything that is known as to the origin of the ' variety ', are given below.

Bramling.

This clone was obtained from Mr. W. W. Berry (later Sir Walter), Gushmere Court, Selling, Kent, who wrote in 1920 : " I have grown them for thirty years ; three years ago I marked specially a number of hills in a garden that came out regularly together and were truest to type ; the sets sent are part of several thousands grown from those marked hills."

The original Bramling was selected by the bailiff on a farm at Bramling, a hamlet in the parish of Ickham, Kent. It came into popular and extensive favour around 1865.

Early Bird.

This was supplied by the raiser, Mr. Alfred Amos, Spring Grove Farm, Wye, Kent, who selected it in 1887. Mr. Arthur Amos writes (12th August, 1948) : " This variety was noticed by my father as a single plant in a garden of Bramlings. It might have been a seedling or a sport."

Eastwell Golding.

This variety, of reputed German origin, was also obtained from Mr. Alfred Amos, whose son, Mr. Arthur Amos, has informed the writer that they were imported by Lord Winchelsea around 1890, to Eastwell in Kent. In Mr. Alfred Amos's experience it has more vigour of growth than either Bramling or Early Bird. Mr. F. N. Clements of Boughton Aluph, writes (18th December, 1948) : " I can only say that it must be a very old variety as it was growing on Tower Farm, Boughton Aluph, in 1889, when my father took over the farm from Mr. George Bishop who had been the tenant since

* Present valuation of Goldings £30-15, Fuggle £27-5 for first grade growths.

1829, and he informed my father that it was originally grown in Eastwell Park on the site which is now a lake, close to the Church. I understand that the lake was dug out about 200 years ago."

In spite of its reputed German origin the variety now grown as Eastwell Golding appears to be a typical English Golding hop.

Canterbury Golding.

This stock was obtained from Mr. F. I. Neame, who wrote : " . . . grown at Macknade Farm from stock that has been on the farm probably as long as the Pethams " (see below). This variety is also known as ' Old Golding ' by some growers.

Mathon.

This variety is the ' Golding Hop ' of the West Midland area. It has been possible to discover little as to its exact origin or whether it has any connection with the Kent Goldings. It was originally cultivated in the parish of Mathon in Worcestershire. The East Malling stock was obtained from Mr. A. R. Firkins, Moor Farm, Eardiston, Worcestershire.

Petham Golding.

This was supplied by Mr. F. I. Neame, who wrote : " . . . from Lower Ensden Farm, Chilham (Kent), raised from hills which I planted from an old garden which had been there for many years ; I believe this variety has been grown on the farm for fifty years or more." Presumably this variety originated in the East Kent village of Petham.

Rodmersham Golding.

This material was obtained from Major Bell through his bailiff, Mr. R. Tanner, who wrote : " We obtained these in 1912 from Mr. W. W. Berry and have since grown them in our garden by Bishopsbourne Station." This variety was originally selected about 1880 by Mr. R. M. Mercer of Rodmersham House, Sittingbourne, from a garden said to be over 100 years old at Malling (original Goldings ?). It was at one time known as ' Mercers Hop '.

East Malling Trials.

By 1943 sufficient stock of Mosaic-free material was available to plant a trial of the seven clones in isolation. Owing to the big difference in season between Bramling and Early Bird and the other five clones, the trial was divided into two parts, one comparing the two early Goldings, and the other the five later ones.

The trial of early Goldings was arranged in ten randomized replications of Bramling and Early Bird, each of 14 hills in a row. That of the later Goldings was divided into four blocks, in each of which the varieties were randomized in two row plots of 24 hills. Adequate pollination was ensured by planting five males in a guard row on the south side of the garden, and four males in a similar row on the north side. The males covered a wide range of flowering times.

Bine colour.

As mentioned in the earlier progress report (Beard, 1943), all the Goldings fall into the mottled bine class, having green bines more or less mottled with red. There was considerable variation in the amount of red colour present from season to season and even between different bines on the same plant. The bine of Petham Golding was, however, definitely more green than that of any of the other selections.

Vigour.

Bramling and Early Bird were of similar vigour and were less vigorous than the other clones with the possible exception of Canterbury Golding. Petham Golding was the most vigorous.

At the beginning of the experiment Canterbury Golding seemed of similar vigour to Mathon, Rodmersham Golding and Eastwell Golding, but towards the end it was so crippled by Downy Mildew and so many hills had been replanted that no accurate estimate of vigour was possible.

Season.

From 1944 onwards the dates on which the varieties came into burr (flower) and the dates in which the young cones started to develop, were recorded. There was no difference between the two earlies, Early Bird and Bramling, but they were distinctly in advance of the other varieties (Table I). Petham Golding came into burr on the average two days before Eastwell and Rodmersham Goldings. Mathon and Canterbury Golding were the last to come into burr, with Canterbury Golding on average a day later than Mathon.

Table I.

Order of coming into burr and hop, and mean dates.

	1944.		1945.		1946.		1947.		1948.		1949.		Mean.	
	Burr.	Hop.	Burr.	Hop.	Burr.	Hop.	Burr.	Hop.	Burr.	Hop.	Burr.	Hop.	Burr.	Hop.
Early Bird	1	1	1	1	2	2	1	1	1	1	1	1	21st July	8th August
Bramling	2	2	2	1	1	1	1	1	1	1	1	1	21st ,,	8th ,,
Petham Golding	3	3	2	2	3	3	2	2	1	2	2	2	24th ,,	13th ,,
Rodmersham Golding ..	3	3	3	2	4	3	3	2	1	2	2	3	26th ,,	14th ,,
Mathon	4	3	4	2	4	4	3	3	2	4	3	2	28th ,,	15th ,,
Eastwell Golding	3	3	2	3	4	4	3	3	1	3	3	4	26th ,,	16th ,,
Canterbury Golding ..	4	3	4	4	4	4	4	4	3	5	3	4	29th ,,	18th ,,
All varieties	Late	Late	Early	Early	Late	Aver-age	Early	Early	Late	Late	Early	Early		

The varieties began to develop their cones in the same order in which they came into burr, with the exception of Eastwell Golding, which, although it came into burr about the same time as Rodmersham Golding, remained longer in that stage and was one of the latest to come into hop, coming between Mathon and Canterbury Golding. The distinction between the early and late groups was more marked in time of coming into hop than into burr (five and three days respectively). The records show that there were definite seasonal variations in both the time of the burr period and its duration.

Cones.

In the seasons 1945 to 1948 samples of cones were taken from the bulk of dried hops of each variety in the oast, and from these samples 50 cones were taken at random and examined in detail. Unfortunately the samples for 1947 were accidentally damaged before they could be examined. A summary of the data obtained is given in Table II, the figures being the means of three years' results. There is evidence that the varieties behaved relatively differently in each of the three years, except in the per cent of seeded bracteoles, but the seasonal effects were not enough to upset the general conclusions indicated by the significant differences shown in Table II.

TABLE II.

COMPARISON OF CONES, 1945, 1946, AND 1948.

	Mean length of cones cm.	Mean number of petals.	Mean number of petals per cm. strig.	Per cent seeded bracteoles.
Eastwell Golding ..	3·4	53	24	31
Mathon	3·4	48	23	56
Petham Golding ..	3·2	53	28	21
Rodmersham Golding	3·0	48	27	23
Bramling	3·0	47	27	31
Early Bird	2·9	47	28	29
Canterbury Golding	2·8	48	28	28
Sig. diff.	*0·12*	*2·2*	*1·2*	*3**

* As the data in this column were analysed after transformation to angles of equal information, the figure for significant difference has been assigned to indicate where differences lie and has not been calculated.

Length of cone.

Although the relative lengths of cones of different varieties were not consistent from season to season, the records in each of the years show that Eastwell Golding, Mathon and Petham Golding had longer cones than the other Goldings with Canterbury Golding on the average producing the shortest cones.

Number of petals.

As would be expected, the number of petals was affected by the length of cone, but Mathon, with a mean cone length comparable with Eastwell and Petham Goldings, had fewer petals. Canterbury Golding had rather more petals than one would expect from its cone length. The number of petals per cm. length of strig varied with the variety, and though there was seasonal variation in the relative order of the varieties for this character, Eastwell Golding and Mathon, both varieties differing greatly in their number of petals, were in each season the varieties with the lowest number of petals per cm. of strig.

Amount of seed.

The petals of a hop cone are composed of bracts and bracteoles in the proportion of 1 to 2, and each bracteole, if pollinated, bears a seed at its base. In Table II is given the percentage of bracteoles bearing seed for the seasons 1945-48. Petham and Rodmersham Goldings always had the lowest proportion of seeded bracteoles, and Mathon had by far the highest proportion. These differences in the amount of seed were not due to the absence of suitable pollen as there were always ample males in flower during the whole burr period. These varietal differences have practical applications under commercial conditions. Sufficient seed is required to give reasonably good cone development and adequate yields, but an excessive amount of seed reduces the market value of the hops. Accordingly it would appear that gardens of Mathon might need fewer than the normal number of male plants whilst gardens of Rodmersham and Petham Goldings might need more.

Cone size and amount of seed.

Salmon and Amos (1908) showed that the size of the cones of Golding hops depends on the number of petals and the proportion of seeded bracteoles. Mathon, Petham Golding and Eastwell Golding had large cones, but with Mathon this was due to a high proportion of seeded bracteoles, as it had fewer petals. If Eastwell and Petham Goldings were as well seeded they would have larger cones than Mathon as they have more petals.

Incidence of pests and diseases.

Each season the whole garden was subject to a big influx of migrating hop-damson aphids (*Phorodon humuli* Schr.), which was satisfactorily controlled by nicotine washes. There was no apparent difference in the severity of attack on the several clones. In 1945 there was a slight attack of Mould (*Sphaerotheca humuli* (DC.) Burr.), but again there did not appear to be any varietal differences in susceptibility.

Although the garden was planted with disease-free material, a few hills developed symptoms of Mosaic disease. The random distribution of the affected hills indicates that infection probably came in from some outside source.

Downy Mildew (*Pseudoperonospora humuli* (Miyabe and Tak.) G. W. Wilson) has been the most serious trouble, and its incidence has shown varietal differences. Records and observations were made on the incidence of the disease on bines, straps* and rootstocks, but not on cones, as these were protected from infection by copper sprays. In 1944 only eight hills in the entire planting developed 'spikes', i.e. shoots characteristically stunted by Downy Mildew, the varieties affected being Canterbury Golding (five hills), Bramling (two hills), and Early Bird (one hill). There were only one or two spikes to each affected hill. In 1945 the attack was still slight, and only basal spikes were developed. From 1946 the disease was more in evidence, there were attacks on the bine in its later stages of growth giving rise to terminal spikes, lateral spikes and infection of the flowering laterals in July. All varieties appeared to be more or less equally liable to severe infection of the laterals in June and July, but varietal differences were apparent in the early part of the season

Table III.

Downy mildew: Number of basal spikes in April and May per 100 hills.

	1945.	1946.	1947.	1948.	1949.	Mean.
Early Bird	27	1	7	9	107	30
Mathon	3	0	33	58	207	60
Eastwell Golding	0	0	69	118	244	86
Rodmersham Golding	0	0	1	144	468	123
Petham Golding	0	0	30	177	1240	289
Bramling	29	6	143	307	1274	352
Canterbury Golding	48	109	850	1130	1143	656
Mean	15	17	162	278	669	228

(Table III). Canterbury Golding produced by far the greatest number of basal spikes in every season except in 1949. Early Bird and Bramling behaved very similarly in the earlier years, but from 1947 Bramling produced progressively more spikes; over the whole period Early Bird had the fewest spikes, whilst Bramling was surpassed only by Canterbury Golding. Petham and Rodmersham Goldings showed few or no spikes until 1948, but in that season and in 1949 they produced large numbers. Petham Golding, however, produced a large number of primary shoots so that the proportion of spikes to healthy shoots was less than with Canterbury Golding or Bramling.

Canterbury Golding, Mathon, Bramling and Early Bird suffered severely from infection of the straps, especially the first two. The severity of attack on the rootstock may be measured by the number of hills that had to be replanted (Table IV).

There was no correlation between liability to bine infection and strap and rootstock infection. This has also been noticed with the new seedling hops raised by Professor Salmon at Wye College (Beard, 1937).

* Swollen below-ground portion of bines, used for cuttings.

TABLE IV.

NUMBERS OF HILLS REPLANTED.

	1944.	1945.	1946.	1947.	1948.	1949.	Total.	Hills in plots.	Per cent replanted.
Bramling	—	—	—	2	5	7	14	140	10
Early Bird	5	2	1	3	10	11	32	140	23
Eastwell Golding ..	1	—	1	3	2	7	14	96	15
Canterbury Golding ..	—	—	6	16	27	14	63	96	66
Mathon	—	—	—	3	11	24	38	96	40
Petham Golding ..	—	—	—	—	—	—	—	96	nil
Rodmersham Golding	—	—	—	—	—	—	—	96	nil

Cropping.

From 1944 the crop from each plot was picked and dried separately and the yield per acre estimated (Table V). Over the whole period Early Bird cropped slightly lower than Bramling, the difference being due to the crops in 1946 and 1949 ; there was very little difference between them in other years. This lower cropping is probably due to the fact that more hills of Early Bird were replanted. Of the five later varieties, the good performance of Petham Golding was largely due to the maintenance of good crops to the end of the period, whereas the yield of Canterbury Golding fell off from 1946 onwards. The reduction in cropping of Mathon from 1948 was particularly severe. The poor yields in the second half of the period may be attributed to Downy Mildew infection of the rootstock and consequent replanting of dead hills (see Table IV) ; this suggestion is substantiated by a significant negative correlation between the total crop of each variety and the total number of hills of each replanted.

TABLE V.

MEAN YIELDS IN CWT. PER ACRE.

	1944.	1945.	1946.	1947.	1948.	1949.	Mean.*
Early							
Bramling	11·34	20·53	15·14	13·61	11·11	13·78	14·25
Early Bird	12·08	19·68	12·36	12·82	11·74	11·34	13·34
Late							
Petham Golding	16·87	23·07	20·68	20·51	16·45	18·00	19·26
Rodmersham Golding	15·79	20·92	19·51	21·50	16·21	14·55	18·08)
Eastwell Golding	16·70	19·84	20·01	20·50	14·37	15·88	17·88)
Mathon	19·91	21·00	15·38	21·50	12·98	9·76	16·76
Canterbury Golding	18·02	19·34	13·15	13·73	6·45	8·44	13·19

* Except for bracketed figures, all means in this column differed significantly.

Ease of picking.

This character formed the subject of a special investigation, which has already been reported (Beard, 1951a). All the Goldings are, owing to their habit of growth, more difficult to pick than the Fuggle and many of the new (Wye) varieties. Bramling, Early Bird and Mathon are rather easier to pick than the remainder.

Preservative value.

Although the Goldings are mainly valued for their delicate aroma and for the flavour they impart to the beer, a reasonably high preservative value is desirable. No figures were obtained from Bramling and Early Bird in 1948 as suitable samples were not available. Of the two earlies, Bramling had the lower P.V. in each season. The Bramling hill originally selected may have had an abnormally low P.V. for a Golding hop, and the original Early Bird hill an abnormally high one. At that time it was not known that there could be much variation in P.V. within a variety, so that no assessment of P.V. was made. The five later Goldings maintained their relative values from season to season, though there were fluctuations in the absolute value. Mathon has had a consistently good P.V. and can be considered a rather richer hop than the other four selections.

Performance of cuts in the nursery.

From 1945-48 trials were carried out to measure the performance of strap-cuts when planted under ordinary nursery conditions (Beard, 1951b). Differences in the number of sets produced by the varieties appeared to be mainly correlated with the susceptibility to Downy Mildew infection of the straps. Petham and Rodmersham Goldings produced the largest sets and also gave the best take.

TABLE VI.

PRESERVATIVE VALUE α-ACID FRACTION OF SOFT RESINS MULTIPLIED BY 10.

Mean of 5 years.		Mean of 6 years.	
Bramling	35	Eastwell Golding	50
Early Bird	66	Canterbury Golding	51
		Petham Golding	51
		Rodmersham Golding	54
		Mathon	61

Means bracketed together do not differ significantly

Discussion.

Possibly the most interesting point brought out by the trials is the great variation in incidence of Downy Mildew attack on the several varieties. This was unexpected in view of the similarity of the varieties in general character. For example, Early Bird is known to be a selection from Bramling yet it has shown great difference in the incidence of Downy Mildew, having produced far fewer basal spikes.

The object of the trial was to compare the characters and performance of the varieties with a view to the selection of early, mid-season and late Goldings of merit and to provide a nucleus of healthy stock for distribution to growers. This object has, in the main, been achieved. Of the earlies, Early Bird must be given preference on account of its great richness and its relative freedom from Downy Mildew basal spikes, its only bad feature being its liability to rootstock injury by Downy Mildew. It is unfortunate that the Bramling clone should have such a low P.V. Possibly further trials may bring to light either a Bramling with a higher P.V. and less liability to basal spikes or an Early Bird less subject to rootstock injury by Downy Mildew. The choice of a mid-season hop is not easy, as both Petham and Rodmersham Goldings have behaved well, though as Petham Golding crops rather better it has been selected for propagation. The selection of Eastwell Golding for the late variety is an easier choice as Canterbury Golding has suffered so much from Downy Mildew attack in the rootstock. Eastwell Golding has cropped well, had few basal spikes and had only a very few hills killed by Downy Mildew.

In view of its reputation in the West Midland area, it may seem strange to find Mathon omitted from the list of recommended varieties, but its reaction to Downy Mildew infection of the rootstock in the later years of the trial makes it impossible to recommend it for general cultivation. Apart from this defect it appears to be a desirable hop with a good P.V., and to be a good cropper when not affected by Downy Mildew in the rootstock. Mosaic-free nuclei of Early Bird, Eastwell Golding, Petham Golding and Mathon have been supplied to growers in the Kent and West Midland areas and are in good demand. It has always been realized that the East Malling clones may not be typical of the varieties generally grown under the same names and more desirable strains will probably be found.

Selection is being continued by the Department of Hop Research at Wye College, where the East Malling clones will be compared with a number of other clones. The East Malling selections are, however, likely to be the only thoroughly tested clones available to growers for some years.

Summary.

A detailed account is given of a trial of seven clonal Golding hops carried out with a view to selecting a short list of varieties for general cultivation. The chief characters of each clone are described and Early Bird, Petham Golding and Eastwell Golding are recommended as early, mid-season and late varieties respectively.

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Fig. 1.

In foreground, circles of ice made by sprinklers on 14 ft. poles; at left, caravan for recording instruments; in background, large circle of ice made by rotary rainer.

Part IV

BULLETINS FOR FRUITGROWERS

PROTECTION FROM SPRING AND AUTUMN FROSTS BY CONTINUOUS WATER SPRINKLING.*

By W. S. ROGERS

How it works.

Water sprinkling to protect from frost is actually a method of heating. Only a little heat is given out as the water cools from the temperature of the water supply (about 45° F. in spring) to the freezing point. The main heating effect is from the latent heat of freezing, 80 calories per gram, given out as the water turns to ice. To put it another way, if 1,000 gallons of water, at the freezing point, turn to ice in the orchard, as much heat is given out as if 800 gallons of boiling water had been brought to the orchard and allowed to cool to the freezing point.

Thus, the temperature of any object on which ice is forming remains at or near 32° F., so long as water is freezing upon it. Now the blossoms of our fruit plants are not critically damaged until about 28° F., so if we can keep them at 32°, or even at 30° or 29°, they are safe from frost damage, even though they may be encased in ice.

A good example of this was seen on 26th April 1950, when a mixture of snow and rain fell, covering apple blossoms in icy slush over a wide area. Though this looked a dramatic disaster, in fact little or no frost damage occurred. Our blossom temperature measurements that night confirmed that the blossoms remained at 32° F.

Experimental results.

Our own studies (Rogers and Modlibowska, 1950) and those of Jeffree (1950), together with experiments in Germany, Holland and the U.S.A., have proved that the principle is sound. Plants successfully protected from frost damage in these various experiments have included apples, strawberries, potatoes, beans, tomatoes and chrysanthemums. Our latest work, from December 1950 to May 1951, included open field tests of various sprinklers including arrays of small rotary sprinklers covering $\frac{1}{3}$ acre, and a rotary rainer covering 0·4 acre. Test plants were forced on in the greenhouse and taken to the experimental field at Bradbourne for trials during winter frosts. We used small fruit trees and potato, strawberry and runner bean plants, all in pots. Fine wire thermocouples, placed in the buds or leaves of these plants and in the air, enabled us to record their temperature from moment to moment in the special caravan that serves as a mobile instrument room.

One of our sprinkler arrays, the morning after a frosty night, and an experimental cherry tree, covered in ice, are shown in Figs. 1 to 3. This tree went through 7° F. of frost, and only 0·2 per cent of its blossoms showed damage.

The sprinkler arrays were moved to an apple orchard near Marden for the blossom season ; but no frosts occurred then, so large-scale orchard tests have yet to be made.

General conclusions.

These experiments will be fully reported elsewhere, but meanwhile the following general conclusions may be drawn.

Amount of water.

The amount of water needed will depend on the severity of the frost. While, in theory, $\frac{1}{30}$ inch of water (750 gallons per acre) per hour will counteract the heat loss by radiation, in practice a larger quantity is needed for safety, since the treated area is limited and there is always some air movement. This matter is still under experiment ; but, as an example, a rate of $\frac{1}{10}$ inch water per hour (equal to 2,300 gallons per acre) appears able to protect fruit blossoms and potato plants from about 8° F. of frost.

It must be emphasized that the water must be applied almost continuously. Sprinkling in the morning *following* a frost is useless.

* Reprinted, by permission, from *The Grower*, with minor alterations.

Equipment.

Any equipment that can supply the required amount of water continuously is suitable. It must, of course, be capable of operating without clogging with ice, and must be reliable. Existing oscillating spray lines can give about $\frac{1}{10}$ inch 'rain' per hour. Some garden sprinklers give rather more and rotary rainers usually much more. Thus the latter, though effective, would be wasteful unless fitted with smaller jets than usual.

A simple reaction-operated rotary sprinkler with $\frac{1}{8}$ inch jet, such as that used by Jeffree (2), covering a circle of 16 yards diameter, at 30 lb. pressure, appears suitable for orchard use. It is likely that further improvements in equipment can be made.

Operation.

Provisional recommendations are: turn on the water when the air temperature drops to 32° F., and turn it off when it rises again to 32° F., outside the sprinkled area. There is no need to continue sprinkling later than this.

Beware of ice forming in the pipes before the water is turned on; particles of ice can easily block the strainers and jets. It is safest to drain the pipes after each operation; but failing this, covering them with straw is a fair safeguard. Have effective strainers at the sprinkler inlets, for it is not easy to clear blocked jets on a dark frosty night.

Correct pressure at the nozzles is important. In small bore pipes carrying a large flow of water pressure drops very rapidly. It is best to test the pressure near the sprinkler in a trial run. Pressure gauges themselves are liable to frost damage unless protected.

If the sprinklers are operated by an electric motor, it is possible to control them with a thermostat placed outside the sprinkled area. We have done this successfully in several small trials.

Is it practical?

Yes, within limits. The needs are, suitable irrigation equipment, a large water supply and a plant that can stand the ice load without breakage. The soil, also, must be able to receive fairly heavy rainfall without damage.

The method has the advantage that it can succeed in quite hard frosts, including wind frosts. Once the apparatus is installed there is little labour cost—in fact, no night labour if thermostatic control is fitted. The high capital cost can be partly offset by using the apparatus for summer irrigation also.

It is clear that the method can be used not only for protection of fruit blossoms from frost, but also for extending the season of certain tender vegetables. I hope that some growers who already have irrigation plant will use it, as an experiment, for frost control on fruit and vegetables on the lines I have described.

Suitable crops for spring protection by existing oscillating spray lines would appear to include strawberries, early potatoes, French beans, runner beans and possibly tomatoes; and for protection from autumn frosts, chrysanthemums, late runner beans and possibly some others.

For tree fruits, small rotary sprinklers on 14 foot poles are suitable, and it may be worth trying rotary rainers, especially if fitted with smaller nozzles than usual.

Acknowledgements.

I would like to acknowledge the valuable and enthusiastic help of my co-workers, Dr. I. Modlibowska and Messrs. J. P. Ruxton and C. H. Slater. I would also thank the following firms and individuals for the loan of equipment: Messrs. British Overhead Irrigation, Ltd., Messrs. Ferraby and Hare, Ltd., Mr. J. H. Jeffree, Messrs, C. P. Kinnell, Ltd., Mr. A. F. Monk, Mr. R. W. Rogers, Messrs. Sigmund Pumps, Ltd., and Messrs. W. Weeks and Son, Ltd.; also Mr. E. Manwaring, for allowing us to use his orchard at Collier Street, Marden.

Summary.

Water sprinkling for the protection of plants from frost damage is discussed in the light of some recent experiments and suggestions are made for the practical application of the method where suitable irrigation equipment is available.

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Fig. 2.
General view of experimental cherry tree laden with ice.

Fig. 3.
Close-up of icicles on cherry blossom after nine hours sprinkling during 7° F. of frost. The ice caused no damage.

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Fig. 1.

Worcester Pearmain apple trees on M.VII, one year from planting as maidens, with an open centre head (left) and a delayed open centre head (right).

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PRUNING MAIDEN APPLE TREES AS BUSHES

By A. P. PRESTON

Maiden apple trees usually do best when pruned soon after planting, unless they are planted late in the season or growth conditions are likely to be unfavourable. Young shoots, varying in number and length, grow out as a result of this first pruning and they form the primary branch framework. Some of these shoots may be selected during the summer and retained to develop into well-spaced branches forming wide angles with the trunk. The other shoots are removed and, as a result, a few strong branches develop instead of the larger number of weak ones that are produced when winter pruning alone is used ; this was very noticeable in the dry summers of 1947 and 1949. The method has been used successfully with some recent plantings at East Malling.

Heading back and notching.

The maidens are headed back to 33 inches to form open centre heads or to 36 inches to form delayed open centre heads. These measurements are taken from the union, which is about 4 inches above ground, and are easily made if a measured stick is used as guide.

Feathers, which are present on some trees, are cut hard back, taking care not to remove the basal buds by cutting into the wood of the trunk. These basal buds may later form shoots.

To ensure that a shoot may grow out sufficiently low down on the trunk to form the lowest primary branch a bud, 10 inches below the topmost bud with open centre heads, is notched ; for a delayed open centre head two buds, opposite one another and about 12 inches below the topmost bud, are notched. In notching, a crescent-shaped piece of bark right down to the wood should be removed about $\frac{1}{2}$ inch above the bud ; a single horizontal knife cut is insufficient. Cut-back feathers are treated as buds and are notched if suitably placed ; two shoots usually grow from such points and increase the choice of shoots later on. Notching is done in March.

Selection of shoots.

All buds are allowed to grow into shoots and the selection is made when they are 4 inches long. If the selection is made before this stage branches with narrow angles will result. The work may be conveniently spread over a short period as varieties seem to differ in the time taken to produce shoots of this length.

Three well-spaced shoots, evenly distributed, are selected to form the primary branches on open centre heads (Fig. 1). Where the topmost shoot is growing too erect it is cut away leaving another shoot growing at a better angle as the first branch.

Five shoots are selected for delayed open centre heads ; two pairs of shoots at right angles and the topmost shoot, which is allowed to grow upright to carry another tier of branches the following year (Fig. 1).

Unwanted shoots and young feathers are removed with a sharp knife.

Some of the buds on maiden trees may grow out to produce blossoms ; these blossoms are picked off, taking care to leave the cluster of leaves in each case ; young shoots often develop from these clusters to make good framework branches.

Care of selected shoots.

All the selected shoots are needed to form the branch framework and should be kept growing without interruption, especially as the others have been removed and cannot form replacements. A watch should be kept for aphids, which can quickly distort the shoots ; rooks also can be very damaging, breaking down the young branches on which they settle.

Summary.

A method of pruning maiden apple trees as open centre or delayed open centre bushes is described.

CAN THE NEW ORGANIC FUNGICIDES HELP THE FRUITGROWER ?

By M. H. MOORE and A. H. M. KIRBY

Since spraying began, English growers have used inorganic copper or sulphur fungicides on apple and pear trees to combat Scab, the chief fungus disease of these hosts. As high-pressure machines replaced low-pressure ones, copper fungicides lost favour because spray damage was accentuated, and that very good fungicide, home-made Bordeaux, became obsolete, at least for dessert apples. So far, no consistently safe form of copper has been found for use after the green cluster stage on all commercial varieties of apple and pear.

Lime-sulphur, the other time-honoured weapon, proved to have several advantages over home-made Bordeaux : (*a*) damage could be more effectually reduced by lowering the concentration applied ; (*b*) both preparation and use were easier ; (*c*) it was effective against Apple Mildew and, to a large extent, against Red Spider ; the latter was increased by Bordeaux. Nevertheless, even weak post-blossom applications could cause leaf and fruit drop in some seasons and districts, especially on the supreme dessert variety, Cox's Orange Pippin, and arsenical damage was likely if lead arsenate were applied at the same time. Elemental sulphur preparations—colloidal, wettable, dispersible—were brought in to overcome the spray damage problems, and these could safely be applied liberally with or without lead arsenate. The slump period following the introduction of these alternatives was ill-matched with their cost, and only more favourable market conditions later led to their wider use. Moreover, they were largely ineffective against Mildew and Red Spider.

To-day, lime-sulphur is still our standard fungicide for fruit trees, but it is to be expected that the present intensive, world-wide research among virtually limitless organic compounds may loosen its hold. Promising competitors are already claiming attention in Britain, and in the U.S.A., where elemental sulphurs have largely replaced lime-sulphur, some of the organic sprays have gained recognition, though it should be pointed out that the spray problems in the two countries are not alike.

The search for new fungicides has received added impetus recently because of the world shortage of many raw materials, especially sulphur. This situation has emphasized what was already known and accepted as relatively unimportant—that the use of lime-sulphur or of elemental sulphur is extravagant of sulphur, and hence that a more economic way of using a given weight of it would be advantageous. The expenditure of this raw material when differing fungicides are used is indicated later in this article.

TRIALS AT EAST MALLING, 1935-51.

Clearly developments could lead to new fungicides containing less, or even no sulphur. Both lines have been followed, and the results of testing some of these materials as foliage fungicides are discussed below. All percentages recorded refer to the active ingredient and not to the formulated product, except where otherwise stated.

I. Compounds containing sulphur.

Dithiocarbamates.

These compounds are derived from carbon disulphide and were introduced as accelerators for the vulcanization of rubber. From one process the product is *nabam* (sodium ethylene bisdithiocarbamate), which is readily water soluble and too phytotoxic for use on apples. It can, however, readily be changed to a much less soluble zinc salt known as *zineb*, which is much safer. A 65 per cent wettable powder based on zineb has been marketed in the U.S.A. and Switzerland. A second process leads to another soluble product, sodium dimethyl dithiocarbamate, which in turn can be changed to an insoluble zinc salt, *ziram*, or iron salt, *ferbam*, both of which have been offered in this country as 50 per cent wettable powders ; they have been marketed in the U.S.A. as ' Zerlate ' and ' Fermate ' respectively. A third process leads to *thiram*, often referred to as TMTDS, TMTD, or TMT, which was among the first to be developed as a rubber accelerator. In this country wettable powders are available containing from 20 to 80 per cent thiram.

Nabam was tested in 1945 and 1946 in collaboration with Dr. H. Shaw, but proved injurious at a fungicidal level on Cox's Orange Pippin. In 1949, zineb became available in the wettable powder form. At 0·13 to 0·2 per cent (=1·3 to 2 lb. per 100 gallons), this material was about equal to 1 per cent lime-sulphur. Similarly, ziram or ferbam, at 0·2 per cent in a sulphite-lye suspension, was usually about equal to 1 per cent lime-sulphur, ziram being slightly the better and showing some eradicant action. Ferbam gives a dark deposit on leaves and fruit, and this might be a serious disadvantage in a dry year or following late applications.

Thiram was the first of the organic fungicides to be tested here, a report on it being included in the Station's Annual Report for 1935, page 198. Various concentrations and formulations have been employed, including an 80 per cent wettable powder in 1951. On the whole, its performance in the field against Scab has varied from poor to quite promising, thus supporting the erratic results of laboratory tests on spore germination. The field results indicate that a concentration of 0·1 per cent or more is needed to give control equal to that provided by lime-sulphur at 1 per cent, and that, in some seasons, its safety on Cox's Orange Pippin might then be uncertain.

None of the compounds in this group shows any consistent promise against Apple Mildew. Their use against Scab would probably be justified only as post-blossom sprays following pre-blossom applications of a more powerful fungicide. Higher concentrations than those mentioned above, or more frequent applications than are usually recommended, might give adequate control of Scab, especially in a dry season, but the cost would then be very high and spray damage could not be ruled out.

Sulphenamides.

N-trichloromethylthiotetrahydrophthalimide (SR 406) is related to several rubber accelerators that have recently come into prominence. It is an exceptionally promising material and is already on the market in the U.S.A. as a 50 per cent wettable powder. It was tested for phytotoxicity here in 1949 at 0·1 per cent of active material and in 1951 at 0·2 per cent, and it caused no leaf damage on Cox's Orange Pippin. At 0·1 per cent each time it proved, in the difficult season of 1951, to be equal to a full schedule ($2\frac{1}{2}$; 2 : 1 per cent) of lime-sulphur for control of Scab on this variety. The cleanest fruits of all were obtained when SR 406 was used post-blossom following lime-sulphur applications at the usual strengths pre-blossom ($2\frac{1}{2}$ and 2 per cent). It is too early yet to assess its effect against Apple Mildew—a first year's results are not promising—but it shows toxicity towards the summer eggs of Red Spider. It appears to be compatible with all the usual insecticides, but not with lime.

II. Compounds containing no sulphur.

Mercurials.

The well-known fungicidal action of mercury has been made available for orchard use in the form of phenyl mercury salts, of which the chloride has been developed commercially in this country ; the acetate and more complicated salts are in use in the U.S.A. and elsewhere, and are now being offered here. *Phenyl mercury chloride* (PMC) has been under investigation here for many years, both in laboratory and field. The early work was done in collaboration with Dr. H. Shaw and Dr. H. B. S. Montgomery, and a progress report was published in the Station's Annual Report for 1944, page 128. This established PMC as one of the most powerful fungicides ever tested at East Malling against Scab spores in the laboratory, but showed also that the concentration for field use would need accurate adjustment if severe damage to Cox's Orange Pippin were to be avoided. Its performance varied with the method of formulation, a sulphite-lye suspension being more effective and more phytotoxic than a preparation on china clay or one on lead arsenate.

Later work has clearly shown an effect of seasonal conditions also on the performance of this fungicide ; in wet seasons it is, like copper, relatively more effective than in dry ones, and is then also more phytotoxic. A concentration of 0·005 per cent PMC* is recommended as the most desirable level for general field use ; 0·01 per cent, which, though highly effective, can cause severe damage both pre- and post-blossom, has occasionally been safely used even on Cox's Orange Pippin in dry seasons, but is too risky. The special susceptibility of Cox's Orange Pippin to damage (chiefly leaf scorch and leaf and fruit drop) by this spray, even at 0·005 per cent in wet seasons, is well established, and one drawback to its general use is the importance of this variety on many fruit farms. There is less evidence for pears, but the indications are that Comice and possibly some other varieties, including Beurré Superfin and Laxton's Superb, are sensitive to PMC in wet weather (Kirby and Bennett, this Report, page 187). In general, PMC at 0·005 per cent is about equal to 1 per cent lime-sulphur against

* This is equivalent to 2lb. per 100 gallons of the powder as marketed in this country in the past few years.

Scab, and it is, therefore, useful post-blossom where lime-sulphur cannot safely be used. Like the organosulphur preparations, however, PMC is ineffective against Apple Mildew at the recommended concentration ; it does not control Red Spider, and early results against Bacterial Canker of cherry are not promising. Like the zinc sprays, it can dry up existing Scab spots when these are thoroughly wetted by the spray. In commercial formulations it has been successfully used for Scab control in this and other countries for several years, and is relatively cheap. Less is as yet known of the merit of the other organomercurials.

Alkyl glyoxalidines.

During the past five years two grades of fungicide have been developed under the code numbers 341C and 341SC ; the latter grade has now been adopted exclusively for use in the U.S.A., and would probably be the grade marketed in this country. These compounds are formulated as the acetates in an inert solvent, and, when diluted in the tank, require the addition of lime to set free the active component.

The 341C grade has caused damage in the U.S.A. at the high temperatures met with there, but neither this grade nor 341SC has caused any significant leaf scorch or drop on Cox's Orange Pippin, even when applied (once) in 1950 and 1951 at three times the strength recommended for Scab control. First tested here in 1949, both grades at 0·075 per cent gave very good control of Scab when used as post-blossom sprays following pre-blossom lime-sulphur, but, in the wetter seasons of 1950 and 1951, control was less satisfactory when these fungicides were used for both pre- and post-blossom applications ; in none of these years were the crops greater than from the trees sprayed with a full schedule of lime-sulphur. Activity against Apple Mildew has been inconsistent and none against Red Spider is to be expected, although there is evidence that predators of this mite are not adversely affected. This fungicide may find a place as a post-blossom spray, especially on sulphur-shy varieties, including Comice pears. It appears to be compatible with all the usual insecticides except HETP and TEPP, which might be weakened by the excess lime.

Dinitrocaprylphenyl crotonate.

This material, which has no short name, was developed in the U.S.A. as a combined fungicide-acaricide in the form of a 25 per cent wettable powder, but was subsequently withdrawn. It is of interest mainly as the only new fungicide showing good results against Apple Mildew ; at 0·025 per cent, it was at least as good as 1 per cent lime-sulphur. It failed at this strength against Scab in 1949, but a new consignment used in 1951 at double strength was much more promising. Although originally offered as an acaricide as well, it failed to control Red Spider in Essex in 1951, and could not be relied on to do this job unaided. More evidence on its performance as a field fungicide is required before a conclusion can be reached.

Quinones.

Certain chlorinated quinones are available in the U.S.A., and some are good fungicides against Scab, but their tendency to cause damage is likely to be a serious drawback, and they have not been included in trials here.

Pyrazoles.

Quite a recent development has been the discovery of highly fungicidal activity in certain nitroso-pyrazoles. Two of them have been examined in the field with promising results, but one caused damage. Further trials will be needed before the merits of these compounds can be assessed.

SAVING SULPHUR.

It is worth looking at the relative amounts of sulphur required to make the organosulphur fungicides, bearing in mind that their fungicidal activity may not depend entirely on their sulphur contents. Although compounds in Group II contain no sulphur in the final active ingredient, it does not follow that sulphur is not used in their synthesis ; thus in the making of the pyrazoles, one route to the phenylhydrazines requires the use of hydrogen sulphide (H_2S) to precipitate tin. Such complications apart, the minimal requirement of sulphur can be calculated for the Group I fungicides. If the percentage of sulphur in each pure compound and the weight used per 100 gallons are known, the weight of sulphur put on in a normal spray schedule can be reckoned. If two pre- and two

post-blossom applications are made, assuming an arbitrary 400 gallons per acre on each occasion, the relative amounts of sulphur applied in the season would be roughly as follows :

Fungicide.	S content per cent.	Rate of application per cent.	Weight of S per acre per season lb.
Lime-sulphur	24 w/v polysulphide S	2·5 ; 2·0 : 1·0 ; 1·0	62
Dispersible sulphur ..	73	0·5 ; 0·5 : 0·35 ; 0·35	50
Thiram	53	0·1 ; 0·1 : 0·1 ; 0·1	8½
Nabam	50	0·1 ; 0·1 : 0·1 ; 0·1	8
Zineb	46	0·1 ; 0·1 : 0·1 ; 0·1	7½
Ferbam	46	0·1 ; 0·1 : 0·1 ; 0·1	7½
Ziram	42	0·1 ; 0·1 : 0·1 ; 0·1	6¾
SR 406	11	0·1 ; 0·1 : 0·1 ; 0·1	1¾

The figures do not take into account the losses of sulphur in manufacturing processes. In making lime-sulphur, only about 60 per cent of the sulphur used appears as polysulphide sulphur, and the figure above would have to be raised to about 100 lb. to give a fair idea of the sulphur used by the manufacturer in providing for the above spray schedule. Similarly, the amounts of sulphur required to make the organosulphurs probably will be somewhat greater than appears above, although no figures are available to the writers for such a calculation. But the fact remains that fairly good control of Scab could, in a favourable season, be obtained with organosulphur fungicides for the expenditure of much less sulphur than is required if elemental sulphur or especially if lime-sulphur is used, with their stronger pre-blossom sprays. This may be possible without appreciable loss of Scab-control if SR406 maintains its promise of 1950 and 1951. It seems unlikely, however, that economy in sulphur will be matched by economy in cost.

THE SITUATION TO-DAY.

The position held by lime-sulphur as a foliage fungicide is very strong. It is undoubtedly effective, especially at 2 per cent or more, against both Scab and Mildew ; it is cheap compared with most competitors so far offered, and it does not consistently cause serious damage, either to leaves or fruit, except on a few varieties and especially in some districts. For make-weight, it will considerably reduce the active stages of Red Spider, although it is now clear that to control outbreaks of this pest a good ovicide is required and, in all probability, fungicides (and insecticides) kindly to predatory insects and mites.

Thus a challenger to lime-sulphur has to measure up well on a number of tests. If, as is probably true for all the materials discussed except the crotonate, it is impotent against Mildew, it must have a marked advantage in other directions. A fungicide that could compete in price would be very interesting, but so far all the organic materials except the mercurials fail to pass in this respect. It is therefore chiefly a chronic shortage of high-grade sulphur that makes them of possible economic importance for fruit. The margin between an adequate fungicidal level and safety to the host is narrow, especially on varieties susceptible to damage, and most of the organic materials are not free from suspicion on this ground. But commercial production of high-quality fruit in bulk, particularly of Comice and Cox's Orange Pippin, does call for safe fungicides. One way out may be to use the organic materials only in post-blossom sprays, relying on the higher concentrations of lime-sulphur or dispersible sulphur pre-blossom to break the back of the Scab-control problem. Elemental sulphur preparations, which nowadays compete in cost with lime-sulphur, are already used post-blossom by some growers, but whether such use can continue depends on the sulphur situation, as, indeed, does the use of inorganic sulphurs pre-blossom. The promising organic candidates, besides the already-established phenyl mercury chloride or its newly-introduced relatives, would seem to be the sulphenamide, SR406, and perhaps the alkyl glyoxalidine, 341, and these are likely to be given thorough trial in the next few years. Both appear to be more likely than lime-sulphur or elemental sulphurs to allow populations of predatory mites and, possibly, beneficial insects to build up in the orchard, and SR406 has definite toxicity towards the summer eggs of Red Spider.

But if a drift away from lime-sulphur is inevitable, something obviously must be found to deal effectively with Apple Mildew, for otherwise this disease bids fair to rival Scab as a first-class menace on susceptible varieties. By and large, we have not found it necessary to worry unduly about Apple

Mildew for the last 25 years or so ; it has been effectively and unobtrusively dealt with while lime-sulphur reigned supreme over Scab. Inquiries about Mildew control became noticeable when elemental sulphur preparations were beginning to replace lime-sulphur in some areas just before world war II, and have now become frequent.

The present era seems to pose a choice for fruitgrowers between the somewhat outmoded idea of an ' omnibus ' spray and the newer conception of organic fungicides each showing specificity for one disease in particular. As we have more than one economic disease in the fruit plantation, and as an organic ' omnibus ' spray may be unattainable, we may come to mixing our fungicides, including in the tank one fungicide for each disease that proves troublesome. If this day is to dawn, most of the organic fungicides will have to be cheaper than they are now, for otherwise it is difficult to see how the farm economy can stand it. Labour costs have been lowered by the introduction of automatic spraying machines, but there still remains some uneasiness as to whether every type of automatic sprayer can give effective cover at the tops of fairly large trees. Mild fungicides will probably depend upon thorough coverage for good performance ; lime-sulphur probably allowed a grower to ' get away with it ' more often than he knew !

Summary.

This paper is a review of results obtained with the chief organic fungicides now under test against Apple Scab and Mildew at East Malling. They are compared for efficiency, safety, and sulphur consumption with standard lime-sulphur and elemental sulphur sprays.

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